The Living Countryside

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Above: The European otter. Recent research shows that the otter is still common in Ireland in 90% of its available habitat.

THRIVING IRISH MAMMAL SPECIES

Of the thirty species of mammals found in Ireland only about one third are indigenous–all the remainder have been introduced throughout the centuries. Some, such as the pine marten and the otter, are much more abundant than populations in Britain, and many seem to be on the increase.

Discussion about the presence or absence of mammal species in Ireland was heated in the 18th and 19th centuries, and many experts have erroneously pledged their reputations on their belief in the existence of different species well into the present century.

Whatever the old arguments, Ireland has fewer species of plants and animals than the neighbouring island of Britain. It possesses 30 species of mammals compared with over 50 in Britain; it has some 69% of the birds on the British list, lacking, for example, the woodpeckers, three of the five species of owls, and half the warblers; it has only one reptile, the viviparous lizard, compared with six on the British mainland; three amphibians compared with five in Britain; and only 45% of Britain's freshwater fishes. And the same is true of the Irish flora, which has only two-thirds of the number of species found on the British mainland.

Why does Ireland lack species? There are some obvious reasons why Ireland lacks the variety of species found on mainland Britain: a greater number have been introduced into Britain; Britain is one third larger and lies through 10 degrees of latitude as against four for Ireland, so it is capable of supporting a wider variety of species because of its more varied climate. It also has a more diverse landscape with a greater range of habitats.

The main factor that accounts for the

The following 30 species of mammals occur in Ireland:
Insectivores hedgehog, pygmy shrew.
Bats lesser horseshoe, Leisler's, long-eared, pipistrelle, Natterer's, whiskered, Daubenton's.
Rabbits and Hares rabbit, mountain hare, brown hare.
Rodents black rat, brown rat, house mouse, bank vole, red squirrel, grey squirrel, field mouse.
Carnivores fox, pine marten, stoat, American mink, badger, otter.
Seals grey seal, common seal.
Even-toed Ungulates red deer, fallow deer, sika deer.

Telling Irish and mainland stoats apart

Above: The Irish stoat is usually smaller than the British species, with just a narrow line of white which does not extend to the upper lip or the edges of the ears.

Left: An historic picture of Irish hares taken at Nutt's Corner airport during Hurricane Debbie in 1953. Hares have been reported at airports throughout Europe, although it is rarely possible to photograph them so near the runway.

Above: Badgers are under heavy pressure in Ireland as their pelts are valuable, being used for shaving brushes which command a high price.

paucity of species in Ireland, however, must lie in the long series of glaciations or ice ages in the past. It is believed that during the last glaciation the whole of Ireland was covered by ice, with the result that most species of plants and animals then living were exterminated. Those found today are thought to have migrated across a land bridge after the retreat of the ice, so today's Irish mammals have had less time to establish themselves than their mainland counterparts (which were not wiped out during the last ice age, since it did not cover the whole of Britain).

Experts differ on the siting of the land bridge and whether there was a land connection at more than one time with Britain and the Continent of Europe, but they generally agree that the erratic nature of the Irish fauna suggests a series of chance introductions during periods of 'connection'.

The fact that Britain has a greater variety of animals and plants indicates that Ireland broke away from the mainland while Britain was still joined to mainland Europe, thus allowing continued migration of species northwards into Britain but cutting them off from Ireland.

Ireland's mammals There is no species of mammal, found in Ireland which does not occur in Britain, although there are a number with a wider distribution in Ireland, mainly because of lack of competition from close food competitors. These include field mouse, pygmy shrew, Leisler's bat, stoat, pine marten, otter and mountain hare.

Two mammals have characteristics which make them racially distinct from the British species: the mountain hare is darker and redder in colour and has longer ears than the same species in Scotland, and the stoat is smaller, and darker with less white below. Neither turns white in winter. Research suggests that stoats in the south of Ireland weigh more and tend to be larger than those in the north of the island. Otters in Ireland, too, are darker in colour and the pale throat patch, very obvious in the British otter, is almost non-existent in the Irish animal.

Eight indigenous species Of the 30 species of mammal found in Ireland, (leaving bats and seals aside), it is probable that not more than eight are indigenous, and date from the post-glacial period around 10,000 years ago. These are fox, pine marten, stoat, badger, otter, red deer, mountain hare and red squirrel. It seems that the other 22 species acquired Irish 'nationality' as a result of introductions, either deliberately or accidentally.

The pygmy shrew may be indigenous, but could equally well have been introduced at an early period by man. The earliest introduced species is probably the house mouse; records show that it has been on the island since neolithic times, followed by what early Irish naturalists referred to as 'the old English black rat' which probably came during the Viking invasions during the 8th to 10th centuries AD.

The hedgehog may have been brought by gypsies as a food supply. It was also kept in kitchens for killing cockroaches. The rabbit was probably introduced to Ireland at roughly the same time as in Britain during the 12th century, and private warrens became important status symbols, as shooting rabbits became a popular sport. The native red squirrel had become extinct in Ireland by the mid-17th century, probably as a result of hunting for pelts and food, and it was reintroduced in the 19th century.

In 1911 the grey squirrel was introduced to Ireland when Lord Granard released a

number of animals from Woburn, Bedfordshire, to his estate Castle Forbes, Co Longford. Within five years over 200 squirrels were shot on the estate and today this species has been reported from 17 Irish counties and is still spreading.

In 1929 three muskrats escaped from a fur farm at Nenagh, Co Tipperary, and five years later 497 animals were finally trapped and the species became extinct. In 1944 coypu were introduced and escaped from their pens and had to be shot by local sportsmen. In the 1950s fur farms for American mink were established; by 1961 the first escapes were being reported and today the American mink is firmly established in river systems throughout the island. The latest discovery is a bank vole population found in 1964 at Listowel, Co Kerry. It is extending its range north and east at a rate which suggests it is a fairly recent introduction.

Deer Deer keeping was not the sign of social prestige in Ireland that it was in Britain, but from the 13th century there are frequent references in records to 'deerparks'. Both fallow and red deer were introduced and by erecting a wall or fence at Glencree, Co Wicklow, the Normans established the first deer park in Ireland. A special herd of white deer has flourished at Mallow Castle, Co Cork, since Elizabethan times. A fallow buck and two does of the red spotted type were released on Lambey Island, Co Dublin in 1889, and within 20 years they had increased to over 100 beasts, distinguished by their long, black-haired coats in winter. The sika deer was introduced by Lord Powerscourt in 1860, and today red, fallow and sika deer roam the Irish countryside.

Wide distribution Most of the 30 species of mammals in Ireland have a wide distribution, although there are exceptions. The common seal occurs in greater abundance in the north-east and the grey seal is more common in the west and south of the island. The pine marten, although reported from almost every county, is more plentiful in the west than in the east, and the lesser horseshoe bat is restricted in Kerry north to Clare.

The distribution of bats is imperfectly known and much work remains to be done on this group of mammals. Bats have been recorded at light-houses, suggesting they may have immigrated from Britain. The status of the brown hare depends on a number of introductions for sport throughout the 19th century. It is reputed to be local on low ground in areas of high coursing interest such as Donegal and Tyrone, but just how common it is at present nobody seems to know. There have also been many introductions of the Scottish mountain hare for hunting and coursing, the latest in 1947.

Mammals on the increase? Recent observations suggest that many species of Irish mammals are increasing. The otter is still plentiful throughout most river systems. American mink, pine marten and the grey squirrel seem to be increasing, while the red squirrel and mountain hare vary between periods of scarcity and abundance. Both the fox and badger are under heavy pressure and are being killed for their pelts at a rate which could cause a serious decline in a few years' time. So far the only species to become extinct within the historic period, apart from the muskrat and the coypu, is the wolf, which probably died out in the latter part of the 18th century.

Finally, there can be no mention of Irish mammals without reference to the extinct giant Irish deer, the stags of which were reputed to reach 2.1m (7ft) at the shoulder.

Above: Part of one of the two herds of white fallow deer in Ireland at Mallow Castle, Cork. They are the oldest Irish herd of deer, and are descended from fallow deer introduced by the Normans.

Below: Hedgehog with young. Hedgehogs were probably introduced to Ireland by gypsies as a source of food.

Identifying hemlocks

HEMLOCKS: NEW WORLD CONIFERS

Most people have heard of the poisonous British herb called hemlock, but few know that the same name also applies to a group of coniferous trees from America and Asia. In Britain, only the American hemlock trees are commonly planted.

Above: The western hemlock is the most graceful of the genus and, in Britain, the most widely planted. It is common in parks and large gardens, and is also grown in plantations beneath other trees since it tolerates dense shade.

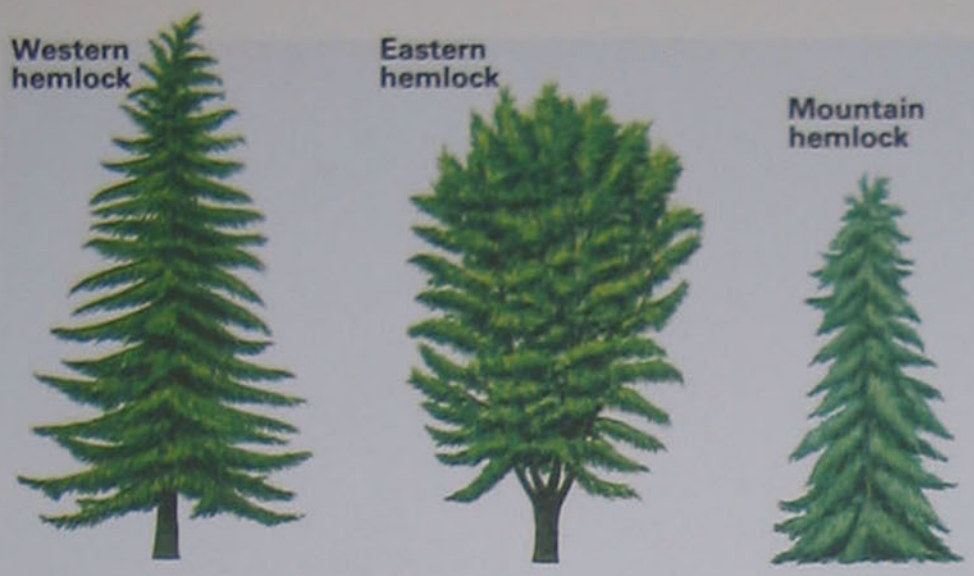
Hemlock trees are a group of conifers from North America and eastern Asia. They were given the name hemlock because the crushed leaves smell somewhat similar to the true hemlock; but there is no relation between the two. The true hemlock is a poisonous broad-leaved herb in the carrot family, whose chief claim to fame–or infamy–is that Socrates, the Greek philosopher, committed suicide in 399BC by drinking a draught made from it.

The botanical name for the hemlock genus is *Tsuga*, which comes from the Japanese name for one of the two species native to that country.

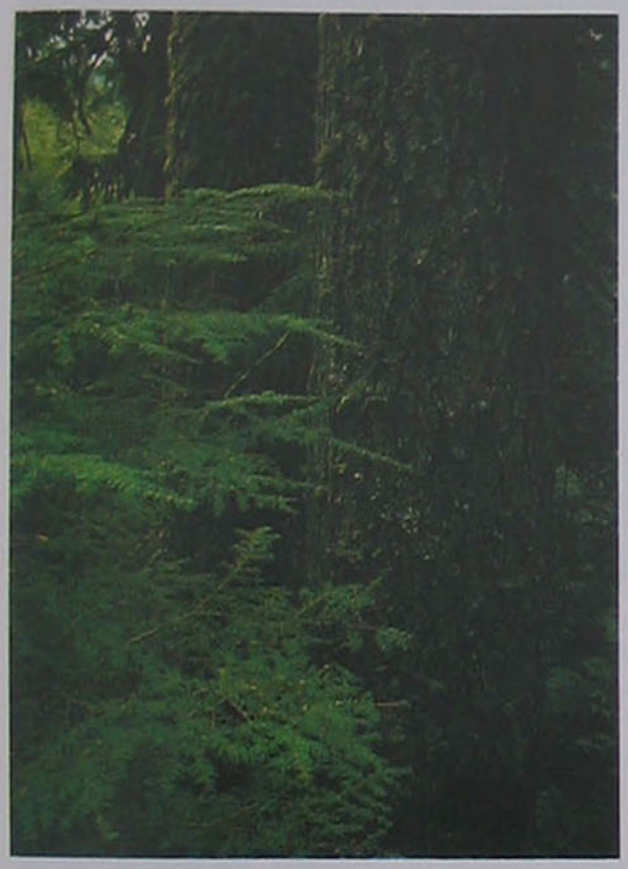
Although hemlocks are not native to Britain, fossil records show that they were growing here thousands of years ago. But they became extinct in the last Ice Age and never naturally returned.

Western hemlock The most common species of hemlock growing in Britain, though not the first to be introduced, is the western hemlock. It is native to western North America, from Alaska south to northern California. Specimens of this tree were first collected by the great Scottish botanist-explorer David Douglas in 1826, but seeds were not introduced to Britain until 1851.

In its native region, the western hemlock can grow to a height of 60-80m (200-250ft), but in Britain few specimens are taller than 40m (130ft), the tallest being a tree 46m (151ft) high at Benmore Arboretum in



Above: The three species of hemlock are easily distinguished at a distance. The western hemlock is the tallest, growing to about 40m (130ft) high, and has a drooping leading shoot; the eastern hemlock reaches 30m (100ft) and its trunk divides near the base; the mountain hemlock, at 20m (65ft) tall, is the shortest of the three. It has a narrow crown with pendulous branches.



Left: The bark of an old western hemlock is fissured, slightly scaly, and purple or grey-brown. On young trees, and high up on old trees, the bark is smooth and dark grey.

Below: The leaves of the western hemlock vary in length from 5-18mm ($\frac{1}{4}$-$\frac{3}{4}$in) and point forwards towards the shoot tip. Each leaf is cigar-shaped, tapering somewhat at each end. The underside has two broad white bands of stomata, through which the leaf breathes. The leaf margins are minutely toothed.

Strathclyde.

The western hemlock has a narrow conical crown whose main characteristic is its pendulous leading shoot–in young trees the tip of the shoot may bend over so far that it grows downwards. The tips of the side branches also hang down.

The shoots are hairy and brown above, paler below. They are covered with ridges on which sit the leaves, in a similar manner to spruce trees where the leaves sit on more distinct 'pegs' attached to the shoots. The leaves are cigar-shaped and dark green above, with two broad bands of stomata beneath. Young leaves are a brighter green above.

The male cones emerge in the spring and are bright red at first, becoming pale yellow when they release their pollen. The female cones are plum-purple when young, maturing through green to become brown when ripe. Mature cones are 2-3cm (1in) long and have comparatively few scales.

Shade tolerant Ecologically, the western hemlock is remarkable for the amount of shade it can tolerate. Because of this, it is now being grown commercially in Britain, in forestry plantations underneath other tree crops. The timber is of moderate quality and is used for pulping and for general softwood purposes, such as boxes and roofing.

The only disadvantage of growing hemlocks is that they are very susceptible to root and butt rotting fungus (*Fomes annosus*, also called *Heterobasidion annosus*) which, as its common name indicates, attacks trees, causing the roots and trunk to rot. In the western hemlock, the rotting can extend 2m (6ft) or more up the trunk, destroying the most commercially valuable part of the tree.

The western hemlock grows well on a range of sites other than shady ones, and it is one of the fastest-growing trees on poor acidic sandy soil.

Less familiar hemlocks Two other hemlocks less often seen in Britain, but still not uncommon, are the eastern hemlock and the mountain hemlock. Both are native to North America, the former coming from the north-eastern United States and eastern Canada, and the latter from the same region as the western hemlock, though at higher altitudes.

The eastern hemlock was the first of the genus to be introduced to Britain, in 1736. From a distance, the most striking difference between it and the western hemlock is that its trunk divides low down into several stems, giving it a shrubby appearance. Close to, the leaves have a noticeably different arrangement for, on the eastern hemlock, there is a line of leaves running along each shoot, with their white stomata uppermost. On the western hemlock all leaves have their stomata facing upwards.

The mountain hemlock is the smallest of the three species, though it has the largest cones–about 7cm ($2\frac{1}{2}$in) long. The leaves are the same colour, grey-blue or grey-green, on both sides. They are borne on small side-shoots called spurs, which look very similar to the rosettes on a cedar tree.

Neither the eastern nor the mountain hemlock is grown in Britain on a commercial scale, but both are fairly common as ornamental trees.

WELL-CAMOUFLAGED SPIDER CRABS

Spider crabs are, to most people, the least familiar of British crabs – not because they are rare but because they are experts in camouflage, covering themselves with bits of seaweed and sponge, and 'wearing' sea-anemones.

Above: All spider crabs camouflage themselves with organic material, some relying on plants or animals such as anemones to grow on them, whereas others collect pieces of sponge, seaweed or anything else suitable for the purpose. Here a species of spider crab, *Hyas araneus*, is gathering seaweed, which it chews before securing it in place. This species is found all around the coast of Britain. It grows to a length of 11cm (4½in).

With their triangular bodies and, in some species, their long thin legs from which they get their common name, spider crabs form a distinct group among British crabs. In all species, the body becomes narrow towards the front and on some it extends forwards to form a 'beak'. The body shell (called the carapace), and sometimes the legs as well, are covered with spines and protuberances. These are a feature of spider crabs and may provide some protection against predators.

Sixteen species of spider crabs occur in waters around the British Isles. Most confine themselves to offshore waters, but a few extend their range into the intertidal region.

Masters of camouflage Many spider crabs are masters of camouflage, which they achieve by two methods, called active acquisition and passive acquisition.

In active acquisition, the crab gathers a covering of plant and animal growths from its surroundings, a process often known as 'masking'. Using its claws, the crab plucks small pieces of seaweed, sponge or other growths from the substrate and fixes them in place on its body or limbs, securing them by means of special hook-shaped hairs on its body surface. Often, the crab chews the pieces before securing them in place.

In passive acquisition, the crab becomes camouflaged as 'spores' of marine plants and larvae of animals settle on the shell and grow. Spider crabs are particularly vulnerable to these growths because they are lethargic, more or less sedentary animals, and also because they do not continue to cast their shells after reaching maturity; growths established on the final shell, therefore, are never discarded.

Their ability to acquire camouflage, combined with their relatively sedentary lifestyle and slow movements, make spider crabs very difficult for predators to detect.

Anemones for protection Some species of spider crab provide themselves with protection by associating with a species of sea-anemone, the snakelocks anemone. An example off parts of our coast is Leach's spider crab (*Inachus phalangium*). The crab sits with the rear of its shell against the anemone's

column, which it sometimes grasps with its last pair of legs. In this position, the crab is almost totally hidden by the anemone's overhanging and protective tentacles. Another species, the long-legged spider crab (*Macropodia rostrata*), has a similar association with the snakelocks anemone. It has been observed to tap the anemone with one of its second pair of legs; the anemone responds by raising its tentacles and expanding its column on that particular side, allowing the crab to adjust its position.

The relationship between the snakelocks anemone and a spider crab works both ways. The anemone protects the crab from predators with its stinging tentacles, while the crab is immune to them–spider crabs have even been seen to crawl over the tentacles without harm. The anemone, on the other hand, benefits by seizing bits of food captured by the crab. In fact, the anemone often eats the greater share, with the crab feeding on the remains disgorged by its companion.

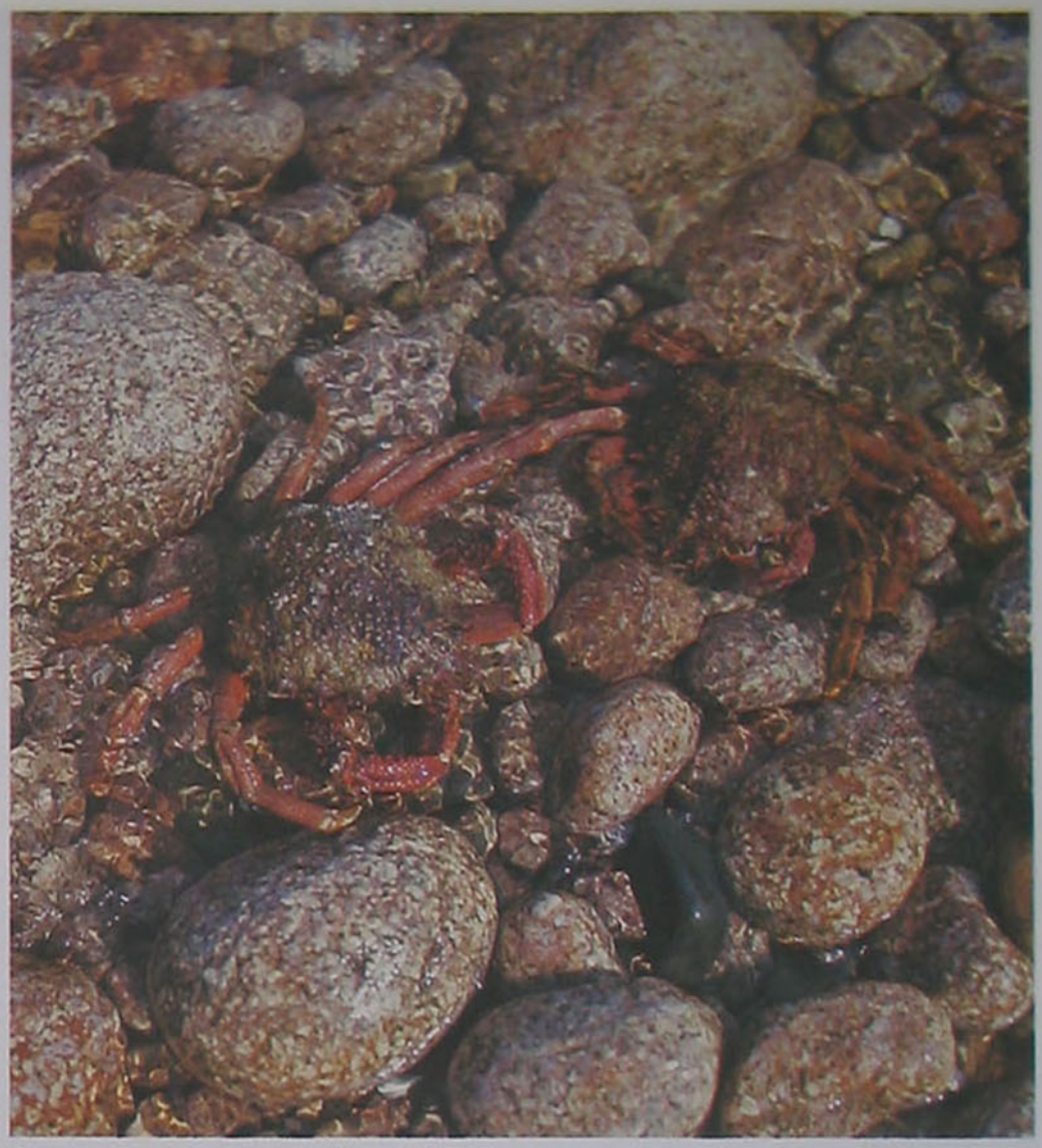
Grazers and scavengers Unlike many other crabs, spider crabs are not predators–they are too slow-moving for that. Instead they graze on algae and colonial animals such as sponges, or they scavenge.

At least one species, the long-legged spider crab (and possibly others in the genus *Macropodia*), has become specialised for feeding upon planktonic organisms. This crab attaches itself to the tips of weeds, hanging there by means of its hindmost pair of legs, which are spined and curved at the ends to give the animal a firm anchorage. Once anchored, the crab appears to sweep its front two pairs of legs through the water searching for food, which it captures with its claws.

Breeding and life-cycle The breeding habits of British spider crabs vary somewhat between different species. Females of the genus *Hyas*, for example the contracted crab (*Hyas coarctatus*), produce only one batch of eggs each year; these require 9-10 months to complete their development. Long-legged spider crabs, however, breed throughout the year and the eggs develop in just 12-15 weeks.

The eggs of spider crabs hatch into minute larvae about 2mm long. They are free-swimming and live in the upper regions of the sea, feeding on microscopic plankton. The larvae resemble shrimps and are known as zoeae. Compared with other crab species, spider crabs have a short larval life, the zoeae passing through only two stages before changing into a more crab-like stage called a megalop. This settles on the sea-bed and moults into a small crab that may show, even at this stage, some resemblance to the adult into which it will eventually grow.

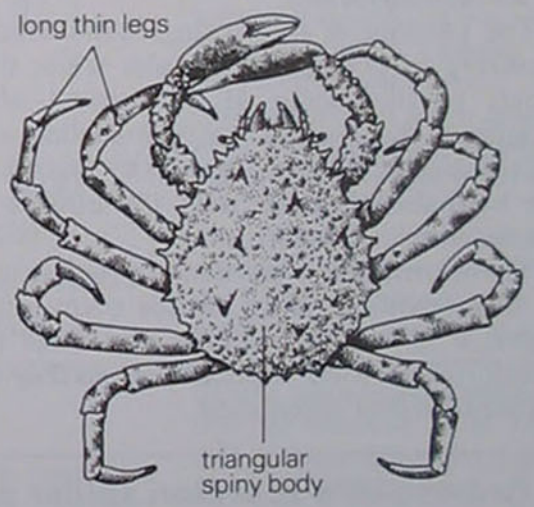
Some British species Most British spider crabs are extremely small. For example, the long-legged spider crab has a body length of only 17mm ($\frac{2}{3}$in), with the scorpion spider crab slightly longer at 2.5cm (1in). Both are

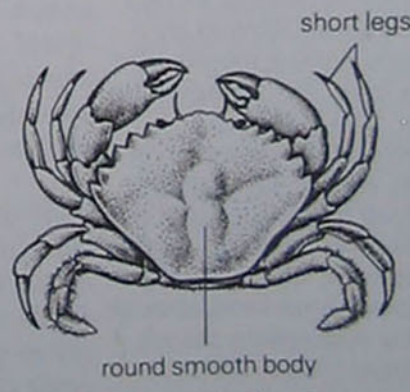


Above: The largest British species of spider crab is the thornback, or spiny spider crab.
The thornback is found along southern coasts on sand and among rocks, from the lower shore down to a depth of about 50m (25 fathoms). Small specimens can be found in rock pools. The colour of its shell can vary from red or pink to white, and may be spotted. Its body length is up to 18cm (7in).

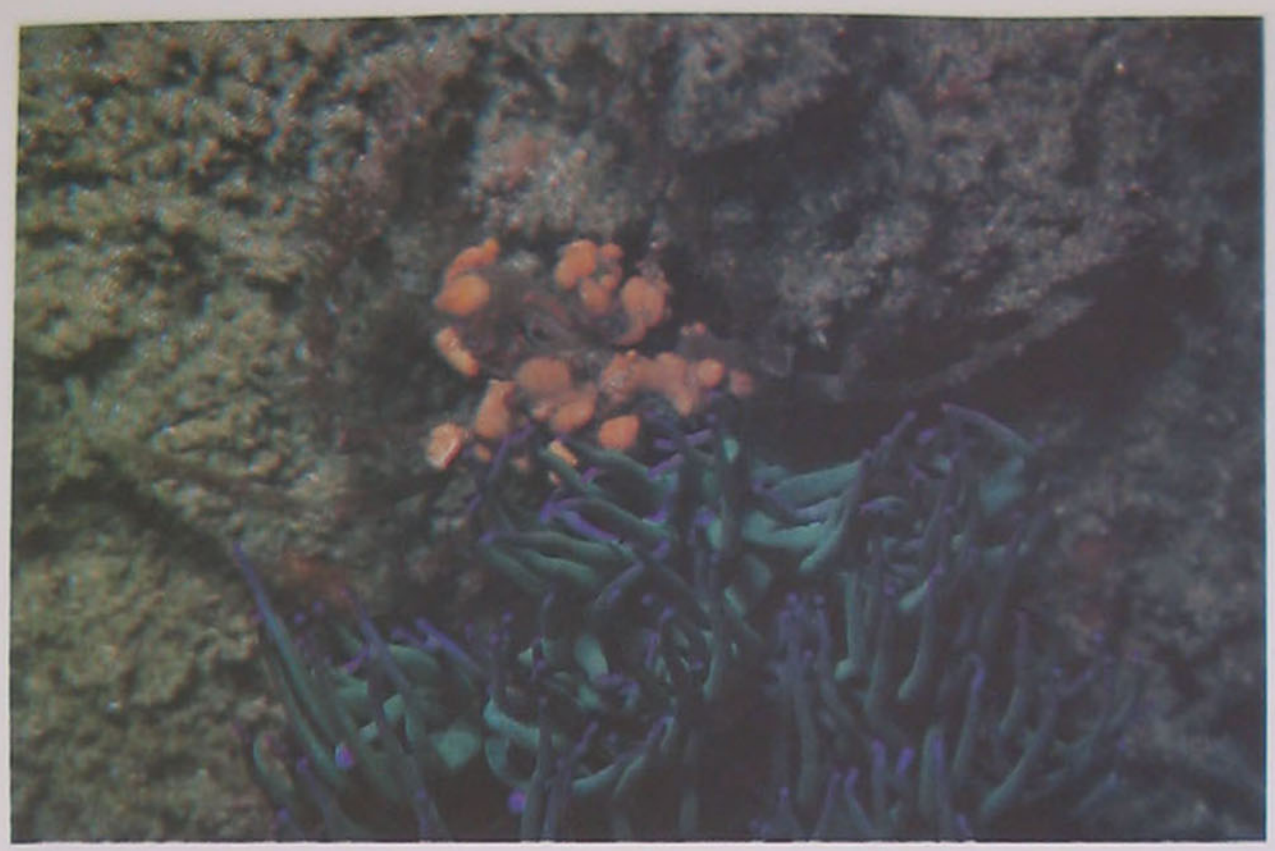
Right: Spider crabs are quite distinct from other true crabs. Their shells are triangular, narrowing towards the front, and their legs are longer and usually thinner than those of other crabs. Whereas most crabs have smooth shells, the shells of spider crabs are covered with spiny protuberances, particularly noticeable on the thornback, shown here with the common shore crab for comparison. Some spider crabs, but not the thornback, have a beak-like extension at the front.

Thornback *(Maja squinado)*





Common shore crab *(Carcinus maenas)*



Left: Leach's spider crab is often seen associated with a snakelocks anemone, the crab sitting with the rear of its shell against the anemone's column so that it is protected by the tentacles. Towards its front the crab has gathered pieces of orange sponge and seaweed to provide further camouflage.

Below: With a body length of no more than 17mm ($\frac{2}{3}$in), the long-legged spider crab is one of the smallest crabs found around the coast of Britain. This specimen has covered itself with pieces of seaweed, held in place with special hook-shaped hairs.

found among seaweed or rocks in shallow or deep water, though the latter also inhabits the lower shore.

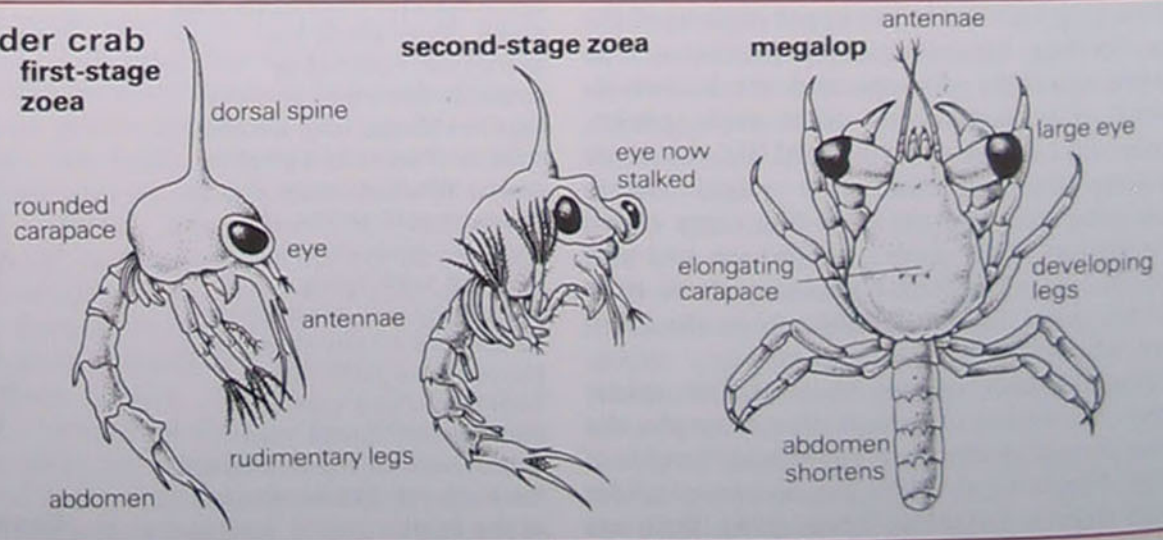
The largest British species is the thornback, or spiny spider crab (*Maja squinado*), which grows to a body length of 18cm (7in). Small thornbacks occasionally occur in rock pools and large specimens are often found in shallow coastal waters, particularly during the summer. At this time of year, many thornbacks congregate in the shallows, where they form huge mounds that can contain as many as 50-100 individuals.

The purpose of this strange behaviour is probably to protect the females while they moult in the centre of the mound–after moulting, the females are soft-shelled and vulnerable. In this condition, they mate with the hard-shelled males near the outside of the mound.

The thornback is particularly well-suited to this behaviour since, unlike many other crabs, it is not carnivorous and does not attack its own kind, especially when they are soft-shelled and defenceless.

Growth of a scorpion spider crab

All spider crabs have a short larval life consisting of two zoeal stages followed by a megalop, which moults into a true crab. For the scorpion spider crab (*Inachus dorsettensis*), whose larval stages are shown here, the first crab stage appears three weeks after hatching. With this species, all three stages are about 2mm long, though usually succeeding stages are larger.



AN OUTSIZE GULL: THE GREAT BLACK-BACK

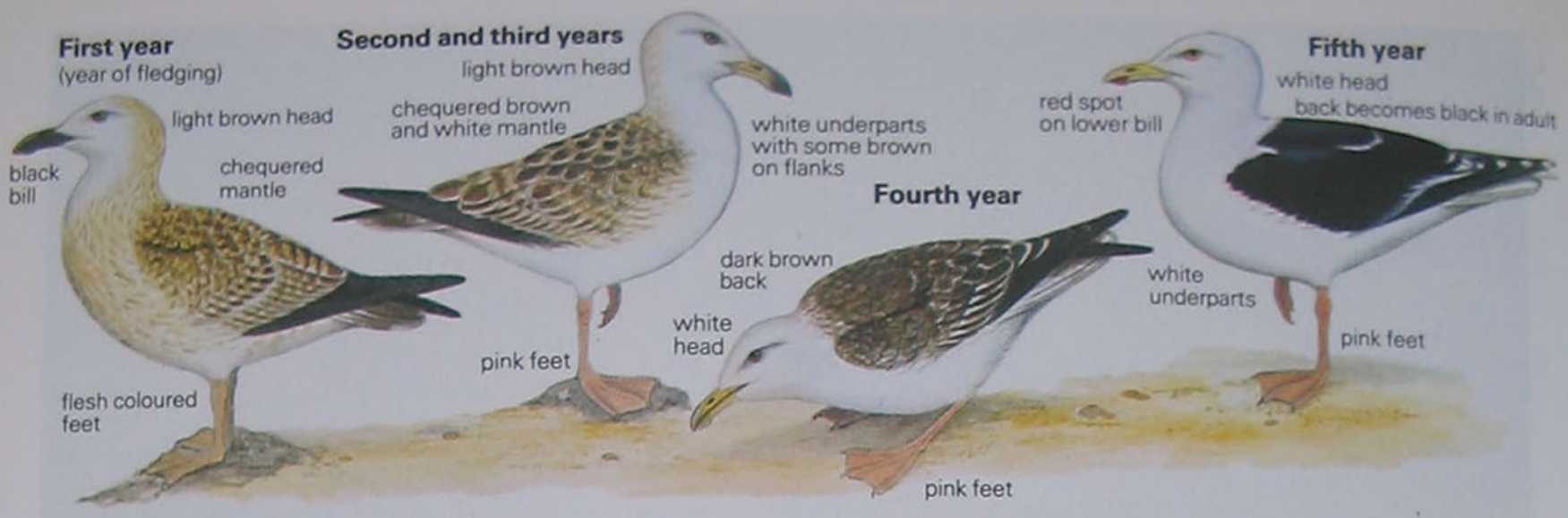
The great black-backed gull is the largest of our gulls, and also the most rapacious. Besides fishing for itself, it eats fishing industry scraps and plunders rubbish tips. It robs other birds of their catch, but is just as likely to eat the birds themselves; and sometimes it even preys on its own species.

Above: A great black-backed gull calling. The calls are a help in identifying the birds. Though of a similar type to the calls of the herring gull and lesser black-back, the great black-back's call is much deeper in tone and harsher. The most characteristic calls, usually produced near the nest in the breeding season, are a gruff, barking 'aouk' and a throatily gutteral 'uk-uk-uk'. During the winter months they are relatively quiet. The gull in the photograph is one of a pair nesting in an isolated spot, not in a colony. These pairs choose high eminences on cliffs or on the tops of rocks for nest sites, and the male always has a number of perches nearby, each commanding a good view. From here he barks a warning to his mate if intruders threaten to come too close.

Because of its enormous size–a head and shoulders taller than gulls of any other species standing nearby–and because of its plumage, which is pure white with striking jet-black wings, an adult great black-backed gull is one of the easiest seabirds to identify. In flight, the broad black wings show a conspicuous white trailing edge, and their slow and steady but immensely powerful beat is another feature separating the great from the lesser black-backed gull. The latter has a faster wingbeat, and is distinctly smaller, being only 53-56cm (21-22in) long in comparison with the maximum of 74cm (29in) for the great black-back.

Further distinctive features of the great black-backed gull are the massive head and the beak, which is sometimes about 7cm (3in) long–powerful enough to tear carrion or the thick skins of other seabirds. Often during the summer months a pair of great black-backs stand side by side near their nest, and it is then possible to separate the two sexes with some ease, as the female is noticeably smaller and slighter in build than the male.

The younger generation Apart from their distinctively large size (a feature useful only when other species are nearby for comparison), young great black-backs are much harder to identify. Great black-backs rarely breed before they are five years old, so there are four different immature plumages, one in



each of the years preceding breeding. The resulting variety is confusing enough, but in addition the birdwatcher has to bear in mind that each of these plumages is roughly similar to one of the immature stages of both the herring gull and the lesser black-back (although these two species resemble each other more nearly than they resemble the great black-back).

In their first full year (from soon after hatching till the following summer) young great black-backs differ from the other young gulls in having whiter heads and underparts, and in having a more clearly marked chequered mantle (upper back). In the second full year, this contrast between a dark

Great black-backed gull (*Larus marinus*); our largest gull; breeds on rocky coasts; winters at sea or inland. Length 74cm (29in).

Below: The bulky nest is situated at the top of the cliffs. Two eggs are the normal clutch, but in this case only one has hatched—the other lies crushed, the victim of some accident. Note the unconsumed squid at the edge of the nest: this was probably found as carrion, but proved unsuitable for feeding to the chick.

chequered mantle and pale head and belly is intensified. As they age further, the mantle and wings of young birds become almost as dark as those of adults, although they are brown and not jet black, and there are still dark bars on the tail and a broad black band at the tail tip.

Colonies and single nests The breeding sites of great black-backed gulls are located along the rocky coastlines of northern and western Britain, most of the Irish coastline, and the rocky islands in these western waters. There are strikingly few breeding pairs on the east coast of lowland Scotland, or on the entire eastern English coast, or again on the south coast from Kent to the Isle of Wight, although non-breeding pre-adult birds may be seen anywhere round our coasts in summer.

In some areas, especially where they are numerous, great black-backs breed in small, scattered colonies, either of their own species or interspersed among herring gulls and lesser black-backed gulls in mixed colonies. Over much of their breeding range, on the other hand, it is common to find single pairs breeding in isolation, choosing the highest promontory on the cliffs or the top of a rock as a site for their bulky nest.

Evidence of a varied diet Around the nest, the remains of previous meals can often be found. Sometimes these take the form of a sizeable 'midden' (refuse heap) of carcases of rabbits and seabirds, but usually there are plentiful castings, or pellets, of undigested remains that the birds regurgitate. Examination of these has shown that great black-backs have a very varied diet, including many species of fish, molluscs and crustaceans, some caught by plunge-diving into shallow waters. Some of the remains are those of deep-sea fish, and it is likely that these were obtained by scavenging at nearby fish wharves or behind fishing boats out at sea.

Attacks on seabirds Studies of the food remains of great black-backed gulls have shown that they sometimes rely heavily on the larger forms of prey: besides rabbits, they especially favour other seabirds. Most include the occasional seabird in their diet, but some pairs seem to specialise in preying on nearby

Above: With such large wings, their flight appears slow and ponderous, but great black-backed gulls are surprisingly fast in the air. They can outpace and seize in mid-air such birds as puffins and storm petrels.

Left: A chick pecks its way out of the egg. For this task it is equipped with a specially tough extension to its upper beak, which you can see as a white ridge. As soon as its down has dried, the newly hatched chick is able to walk and scamper about. The down is greyish-fawn with black camouflage markings, making the chick inconspicuous in the nest until it rushes out to greet a homecoming parent. By pecking at the red spot at the tip of the lower part of the beak, it stimulates the parent bird to regurgitate the meal that it is holding in its crop. The chick accompanies these agitated pecks with a series of piercing, wheedling cries.

seabird colonies and can wreak considerable destruction. The eggs and young of any seabird that nests in an exposed site are vulnerable, including other gull species and occasionally even neighbouring great black-backs, seized in a cannibalistic attack.

Of the adult seabirds caught, many are of species that are ungainly on land, such as the puffin and the Manx shearwater, which seem especially helpless. Young shearwaters, emerging from the safety of their burrows to exercise their wings prior to fledging, are particularly vulnerable on moonlit nights. It has been estimated that in the mid-1950s a population of 200-250 pairs of great black-backed gulls on Skomer, an island off Pembrokeshire, accounted for a total of more than 5000 shearwaters and puffins. Fortunately these two species breed in huge colonies (over 100,000 pairs on Skomer), so they can usually–at least for a while–survive this carnage.

Once the prey has been caught, it is occasionally swallowed whole in mid-air. More commonly, it is despatched on the ground with a few hammer-like blows from the powerful beak. Seabirds such as Manx shearwaters and puffins have thick, tough skins, which the gulls deftly remove. A sharp snip of the beak at the throat and tail, a flick of the powerful neck, and the body comes clear of the skin. A couple more bites sever the wing bones, and the carcase is then consumed, leaving an inside-out skin, with head and wings attached, as characteristic evidence of the predator responsible.

Spreading inland Although it remains the most maritime of our gulls, being found far out to sea, the great black-back is undergoing a change in its winter distribution. Adults, and especially immatures, can be seen close inshore anywhere round our coasts in winter, often near fishing ports or sewage outfalls. Inland, too, the birds are rapidly widening their range, and there are few refuse tips that do not attract some great black-backs during the winter months. When it comes to scavenging, they may not be as nimble as the smaller gulls, but more than make up for this by depriving other birds of their scraps–by sheer, brutal bullying power.

With their large, sharp beaks and strong muscles, they can even open the carcases of dead sheep or stranded dolphins. Wherever either carrion or human food waste is to be found, the great black-back is among the foremost competitors to consume it. Thus for birdwatchers in the eastern half of Britain, the best place to find this, the largest of our 'seagulls', is inland, on the nearest refuse tip.

Growing numbers In 1969-70 Operation Seafarer, a breeding season survey of our seabirds, showed the great black-back, with around 20,000 pairs (three-quarters of them in Scotland), to be the scarcest of the 'every-day' gulls. Despite this, the increase in numbers and spread in range since the middle of the 19th century has been considerable. In the north of its range, this is thought to have been due to warmer weather which has encouraged breeding and improved the rate of breeding success during the present century.

For the majority of our seabirds in this age of pollution and interference, an increase in numbers would always be welcomed. In the case of the great black-back, however, any welcome should be tempered with caution. This elegant and powerful gull, thriving on man's waste, is always ready to prey on other seabirds. When the supply of unnatural bounty falls short of requirements, the result can be a serious fall in numbers for some of our most attractive seabird species.

Below: A great black-back with its catch, on the quayside.

WOODLAND GLADE BUTTERFLIES

Although large and often vividly coloured, some woodland butterflies can be difficult to spot among the trees in which they live, but late summer flowers, and even the rotting fruits of autumn, may attract them down to feed.

Above: Recent research has shown that the delicate adult wood whites (*Leptidea sinapis*) live for only a week on average, although some individuals survive for up to a month. During their short lifetime the females lay 30-60 eggs, a large percentage of which are eaten by predators before they hatch. Although several types of larval food plant are used, the female butterflies prefer to lay their eggs on meadow vetchling, bitter vetch and bird's-foot trefoil.

An ideal butterfly wood is one with a mixture of open glades and mature trees, interspersed with sunny rides. Our ancient woods were of this type, with sunny glades and luxuriant undergrowth, and dominated by oak–a tree seldom planted today because it thrives only on deep, rich soils.

However, our current practice of planting woodland remnants with economically sensible, but alien, conifers is accelerating the loss of ancient woodland. Once the conifers have matured, the number of butterfly species to be found in these woods fall dramatically.

Although at least 20 of our native butterflies are associated with woodlands, four species–the purple emperor, white admiral, wood white, and comma–can be considered as true woodland butterflies.

The comma butterfly This is perhaps the odd one out among the four species as it is frequently found in gardens. It is, however, still considered to be a true woodland species, females preferring to lay their ribbed eggs on nettles in woodland clearings. Other larval food plants include wych and common elm, hops and redcurrant.

Comma caterpillars resemble bird droppings, having black and white markings, the arrangement and shape of which change at each moult and help them to deceive vertebrate predators. When full-grown, the caterpillar selects a sturdy leaf and spins a pad of silk from which the chrysalis is suspended. This is brown, with small gold specks and blotches, and irregular in shape, like a dead leaf.

Eggs laid in April and May produce a generation of butterflies in July, which may include a number of specimens with pale undersides. This variety is called *hutchinsoni*, and its colouring is thought to be genetically controlled. When the July brood lays its eggs, the generation of butterflies produced from them in August and September are all normal comma butterflies.

In the autumn, the adults feed on the nectar of thistles and ragwort flowers before they go into hibernation for the winter.

Unique white butterfly The wood white is

unique among British whites in being our only representative of the sub-family Dismorphiinae, an almost exclusively South American group. This delicate white butterfly can be recognised instantly by its slow, bobbing, fluttery flight. Both sexes have a black tip on each forewing, although this is rather paler in the females.

Female wood whites prefer to lay their eggs on vetches and bird's-foot trefoil in shady woodland rides. The caterpillars are green and blend in perfectly with the colour of their food plants, making them very difficult to find. They mature quickly and form chrysalids on the growing plant, in which they normally overwinter. Thus the wood white may spend up to 10 months of the year as a chrysalis, although in certain years two generations are produced – the normal one in May to June and a further brood in July to August.

Graceful white admiral Although strikingly black in colour on its upper wings, with white transverse bands, the white admiral is not as conspicuous as one might expect. The contrasting colours break up the outline of the wing, camouflaging it in the dappled light of the woodland.

A graceful butterfly, flying with a strong but elegant gliding motion, it feeds on bramble blossom and honeydew. The females lay eggs singly on wisps of honeysuckle growing in dense woodland.

The first two caterpillar stages feed in a very characteristic way, spinning a pad of silk along the main vein of a leaf and eating either side of this pad, camouflaged by their own droppings mixed with silk. As autumn approaches, the caterpillar forms a tent of leaf tissue called a hibernaculum. Before settling down in it for the winter, it secures the leaf to the honeysuckle stem with silk, so that it does not fall off with the other leaves.

The caterpillar awakes in spring and after a brief spell of feeding it moults to reveal a spectacular, spiny green skin. Eventually, it forms a green and gold chrysalis. Unfortunately, both the large caterpillars and chrysalids are eaten by birds and attacked by parasitoids, and many of them never reach the adult stage.

White admiral
(Limenitis camilla)
wingspan
6.5cm (2 1/2in)

Purple emperor
(Apatura iris)
wingspan 7.5cm (3in)

Comma *(Polygonia c-album)*
wingspan 5.5cm (2 1/5in)

Right: When the purple emperor caterpillar hibernates in the fork of sallow branches during the winter it is camouflaged perfectly, changing colour to match its surroundings.

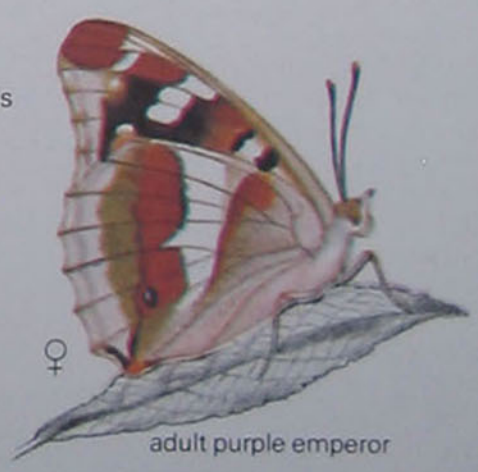
Below: The comma butterfly takes its name from the white comma mark on the underside of its wings. The shape and sombre colour of the wings help the comma to resemble a dead leaf. This protects it during its winter hibernation among ivy.

Life-cycle of the purple emperor

After its first moult, the small green caterpillar of the purple emperor resembles a velvety green slug, with prominent horns. It is well camouflaged on the sallow leaves where it feeds. In November, it hibernates in a fork on the sallow branches, moulting the following June to form a pale green chrysalis which resembles a leaf shoot. The adult butterfly is on the wing from mid-July.

caterpillar feeds on sallow

leaf-like chrysalis



adult purple emperor

Majestic purple emperor One of the earliest species to be recognised in the 17th century, the purple emperor was once known as the Emperor-of Morocco. The wings of the males have a rich purple-blue sheen which can only be seen from certain angles.

Female purple emperors are rarely seen for they spend virtually all their lives at tree-top level, particularly around oak trees. They come down only to lay their eggs singly on the upper side of sallow leaves. Males also spend much of their time in the tree tops, chasing off other males that approach their territory, although they sometimes come down to woodland rides to drink at puddles or feed on carrion or dung.

Fluctuating numbers All four species are linked by a common feature: they have all undergone dramatic changes in distribution over the past century. The best known case is that of the comma butterfly which, after occurring over most of southern England in the late 19th century, became restricted to the Wye valley in the early 1900s. Since then, it has gradually returned to its old localities and is now found as far north as Wales.

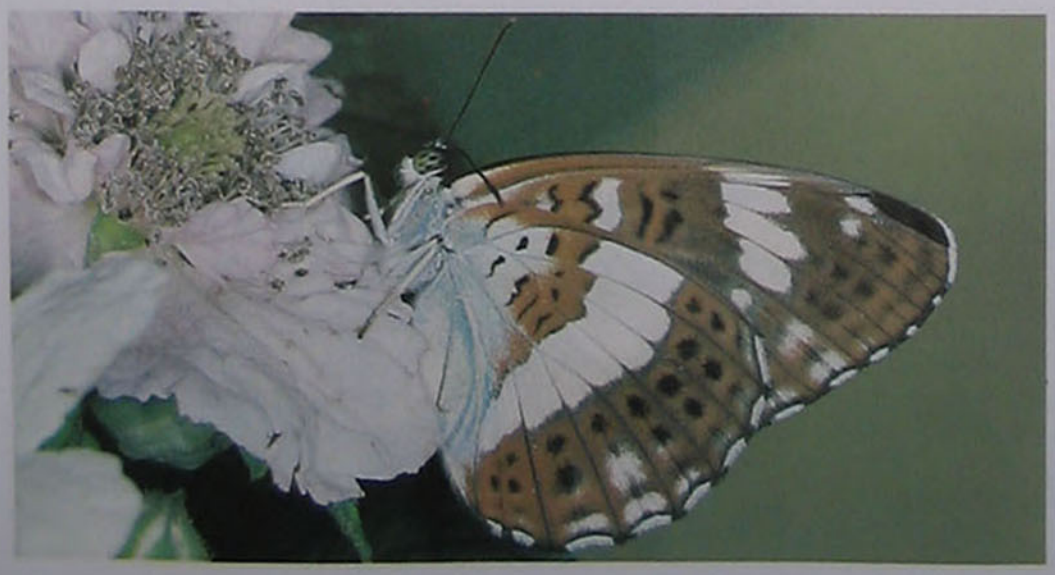
The most likely explanation for such fluctuation in numbers is a change in climate in the early part of this century. It appears that, in the early part of the 20th century, summer temperatures were cooler than average and corresponded with a period in which the range of these species retracted. When the weather is cool, caterpillars take longer to grow and are therefore vulnerable to predators for a longer period. Also, adult butterflies are relatively inactive in cool conditions and die before they have laid their full complement of eggs.

After this period of decline in the early 1900s, all four species mentioned above underwent a dramatic increase in numbers. This coincided with a series of warmer-than-average summers in the 1930s.

Unhappily, population numbers are now falling again and with the decline of suitable woodland, we can only hope that by the time these species recover and begin to spread again, enough of their habitats will be left to support them.

Above: The chrysalis of the white admiral is an unusual combination of green and gold. The gold, or occasionally silver, markings are believed to mimic drops of rain on the chrysalis, which resembles a withered leaf. If the chrysalis is disturbed by a bird, it is capable of violent wriggling movements.

Below: White admirals are commonly seen feeding on sunlit patches of bramble blossom along woodland rides.



What do butterflies eat?

Nectar is the food of many butterflies, but in woodland many flowers bloom in the spring before the tree cover shades them out—too early to provide a source of food. Such woodland species as the comma (below) and peacock feed on rotting fruit in the autumn, while other species rely on the honeydew which coats tree leaves in the summer. Apart from honeydew and bramble blossom, the white admiral has an unusual choice of food—cuckoo spit, which is rich in sugars and amino acids. The male purple emperor has rather unsavoury feeding habits—he visits muddy puddles, carrion, urine and dung for essential minerals.

The seashore, particularly the rocky shore, harbours a wealth of animal and plant life. Careful searching reveals much that the casual beachcomber may fail to see.

Britain's rocky shorelines are confined mainly to the southern and western coasts and are primarily the result of geological formations which occurred before the last Ice Age. However, other factors–such as weathering and erosion–have since played their part in shaping our coast and produced a variety of rocky shores. Some, like Hartland Point in North Devon which is pounded by the full force of the Atlantic, are almost devoid of life. Others, like the sheltered Freshwater Bay on the Isle of Wight, provide a rich and diverse habitat for many kinds of plants and animals.

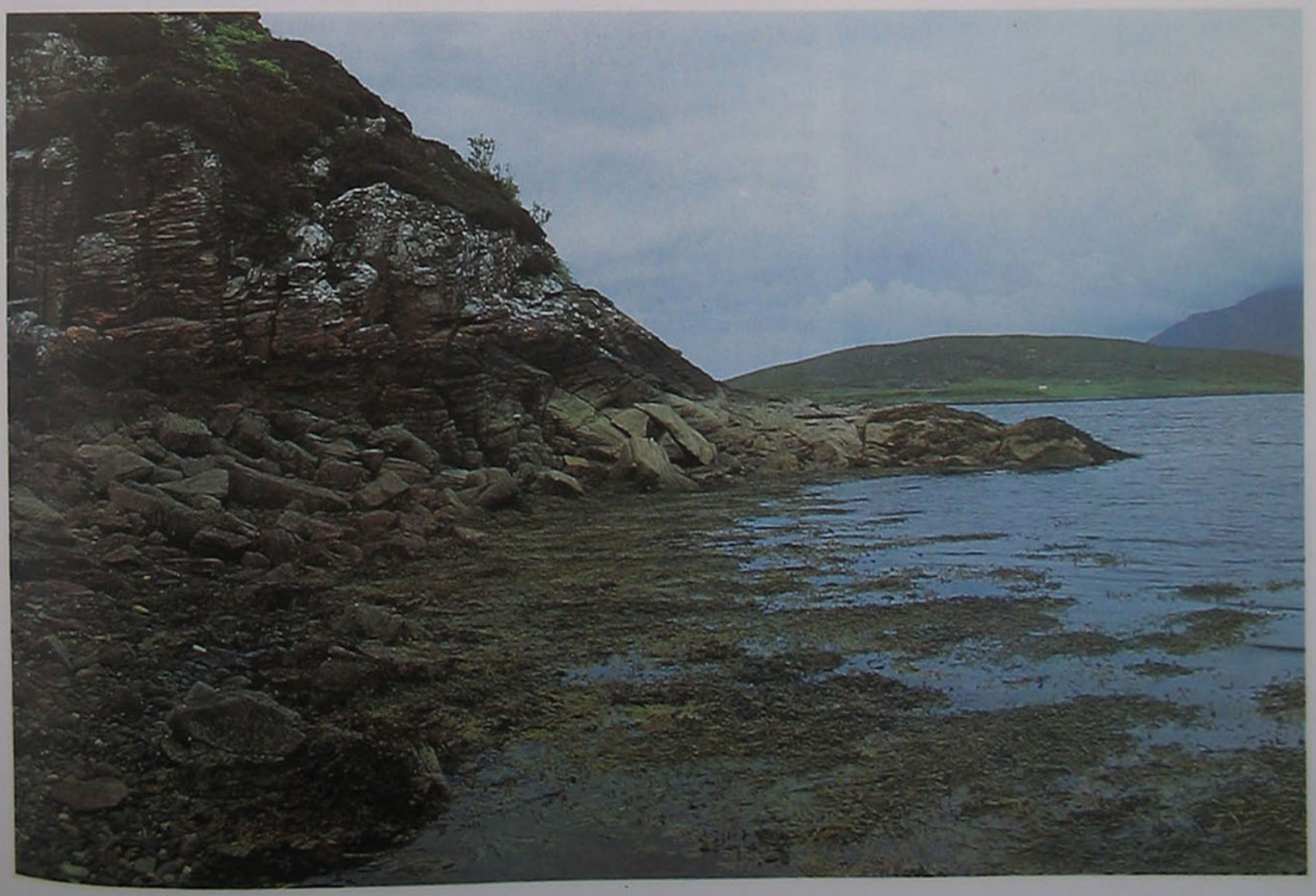
We shall concern ourselves here with an examination of the more placid types of rocky shore where animal and plant life has less to contend with from the elements. However, it should be remembered that even on such shores life can be difficult. In addition to alternate inundation by the sea and exposure to the sun and rain, the mood of the sea can change rapidly–particularly in winter. Some protection from the incessant pounding of the waves is of great importance to life on a rocky seashore.

Bear this fact in mind when you explore the rocky shore, for many of the animals will be hidden from view. Careful searching among the seaweed and under the rocks usually reveals an amazing variety of creatures.

Making a start Always check the tide times before you set out. The best time to visit the shore is just before low water when you will have the opportunity of seeing birds such as oystercatchers and dunlins waiting on the rocks for the tide to recede, and you will have the benefit of the lowest water mark for your

Above: The best way to study birds on the seashore is to crouch low on the rocks, with binoculars trained near the water mark, waiting for them to catch your eye as they move.

Below: Plant zonation on the rocky shore. Lichens and flowering plants are least tolerant of salt water spray and grow furthest away from the sea. On the rocks themselves, the seaweeds grow in distinct bands of species, depending on how well they withstand exposure.



exploration.

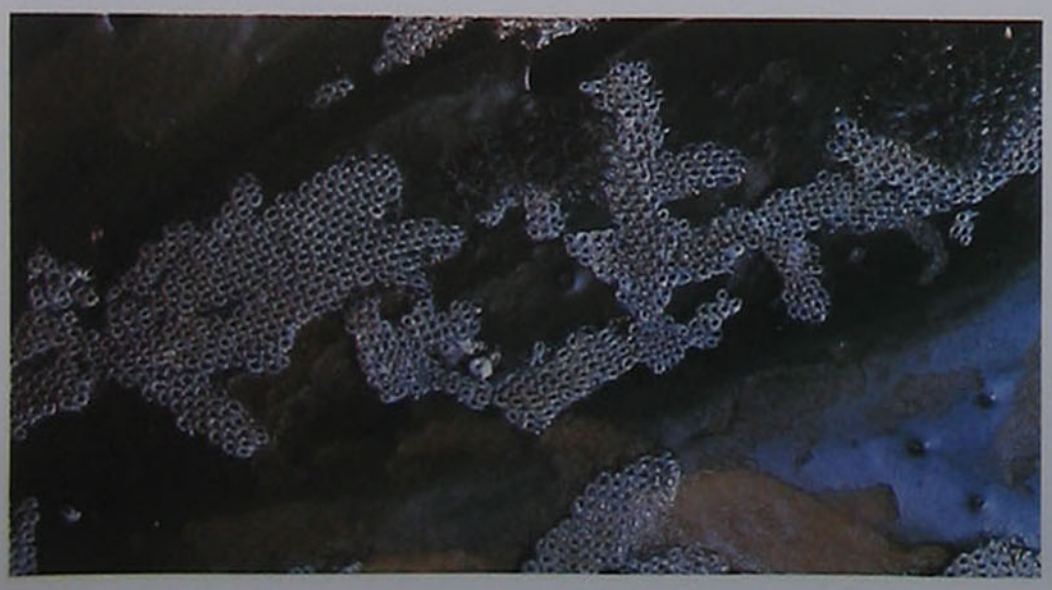
Being marooned by the tide is a frightening experience and potentially dangerous, but it can be avoided by these simple precautions. Always start at the low water mark and work your way back up the beach with the incoming tide. It is all too easy to be cut off if you are exploring in the opposite direction. Similarly, if you are investigating round headlands, calculate how long you can explore before your path back to the main beach is cut off.

The plant life on a rocky shore can be divided broadly into two groups: splash zone plants (mainly lichens and flowering plants), and seaweeds which can tolerate total immersion. Both groups of plants exhibit one of the most important features of the rocky shore–that of zonation.

Above: On the middle shore, sea snails such as whelks, periwinkles and topshells are very common. They creep about on the seaweed when the tide is in, hiding underneath it when the tide recedes. Lift the seaweed carefully and look beneath it, and search in the crevices in the rocks where rough periwinkles like these may be sheltering. The colour of many of the species is very variable and a field guide is useful for identification.

Left: When looking for creatures on the lower shore, it helps to lift stones slowly, since this reduces the turbidity of the water, and alarms the inhabitants of small pools much less, thus allowing you a clearer view.

Below: Each of the tiny cases which cluster together here, encrusting the fronds of seaweed, contains a tiny animal known as an ectoproct which filter-feeds small food particles from the sea.



Plants of the splash zone The splash zone is the uppermost part of the beach, and only covered in extreme high water conditions–during a storm, for example. The lichens and flowering plants of this zone are usually found on the rocks beneath the cliffs.

On these rocks the lichens clearly show a vertical zonation. At the bottom, nearest the high water mark, search for the tar lichen which looks remarkably like an oil spillage on the rocks. Above this, the yellow and orange lichens such as *Xanthoria parietina* and *Caloplaca thallincola* take hold, with the grey encrustations of the *Lecanora* lichens appearing above them. All these lichens grow in small patches or bands–don't look for large shrubby growth as lichens are usually flat and may look structureless to the naked eye.

Seaweeds These are by far the most obvious and abundant plants of the rocky shore. The brown seaweeds are the most common; they do not grow randomly on the rocks but arrange themselves in vertical bands, according to their ability to withstand desiccation.

The most abundant seaweeds on the upper shore are the wracks, in particular channelled wrack. This takes its name from the deep groove along one side, which makes it instantly recognisable. The names of some of the other wracks found here are equally indicative of their appearance–for example, the fronds of knotted wrack are dotted with air bladders.

The middle shore is characteristically colonized by more wracks–bladder wrack, toothed wrack, and also spiral wrack. Note the long, pliable, slippery fronds and (in some species) air bladders–all adaptations to help them survive the pounding waves.

On the lower shore, thong weed, oarweed and tangles predominate–species which can only survive for short periods without water. Some of the larger kelps on the extreme lower shore are attached to rocks by branching holdfasts. Should you find any detached examples which have been washed up, inspect them closely. Interesting worms, molluscs, and arthropods often shelter here.

If you find a seaweed that looks like a long, crinkled green tube this is *Enteromorpha*, one of the green seaweeds. Another common species resembles a piece of soggy lettuce–hence its common name, the sea lettuce. Look carefully here for small, well-camouflaged crabs whose bodies exactly match the seaweed in colour.

Red seaweeds are also present, but as they normally grow in permanently submerged conditions, they can be difficult to spot. One or two species can be found living on the rocks above the water line (the chalky coated *Corallina officinalis* for example), but the majority are to be found living in rock pools.

If you see what appears to be thick pink or red paint coating the sides of a rock pool, you have found one of the encrusting species of red algae.

Animal life on the rocks Part of the excitement of rocky shores is the fact that you never know just what you will find nestling among the seaweed or lurking in a rock pool. Since most of the animals have to cope with the same problem of desiccation as the seaweeds, they are usually found in places that offer them some protection.

On the upper shore, barnacles and limpets are found on the rocks, secure inside their shells while they wait for the tide to come in.

The middle shore, covered more frequently by the sea, is the home of many gastropod molluscs such as periwinkles, whelks and topshells. Often brightly coloured, these sea snails creep about on the seaweed when the tide is in, and can be found sheltering among it when the tide is out. They are revealed by lifting the seaweed carefully and looking among it; remember to replace it after your investigation.

Rock crevices, and the sides of rock pools, are good places to look for many small molluscs. In addition, you may also find bristleworms (distinguished by their 'bristly' appendages), ribbonworms (which are smooth and ribbon-like), crustaceans such as crabs and shrimps, and bryozoans, which resemble small pieces of white gauze attached to the seaweed. Small blobs of jelly found on the rocks when the tide goes out are beadlet sea-anemones, which 'blossom' when covered by the water. Look out for them at the base of rocks in small pools of water.

Sea anemones, sea urchins, starfishes and small crustaceans can be uncovered by searching among the seaweed or lifting stones on the lower shore. Submerged seaweed can be raised with a stick or piece of driftwood, and may be found to house stalked jellyfish, which look like tiny orange umbrellas attached to the fronds. Lift stones carefully to avoid disturbing the sediment, but be prepared for any exposed creatures to dig themselves quickly out of view.

The most common species of fish to be found in rock pools are butterfish and gobies, but you will need to be patient to see them – they usually dart for cover at the first sign of your approach. Therefore, sit quietly by the pool with the sun in your face (to avoid casting a shadow) and wait for the inhabitants to show themselves. Sooner of later they will appear.

Birds and mammals Seashore feeding birds such as oystercatchers have a unique knack of moving away imperceptibly at your approach. The best method of seeing them is to crouch low on the rocks with a pair of binoculars to help you catch sight of them as they move along the shoreline in search of food.

Above: You can find blue-rayed limpets on fronds of oarweed on the lower shore, while many anemones, like this strawberry anemone (right), live in crevices and rock pools.

Getting into gear

1. Wellington boots prevent feet getting wet, but at the very least wear rubber-soles for a secure foothold on seaweed-coated rocks. Do not go barefoot – shell fragments, jagged rock or glass can cut deeply.

2. Warm, waterproof clothing is essential on all but the warmest of days – exposed seashores can be very chilly.

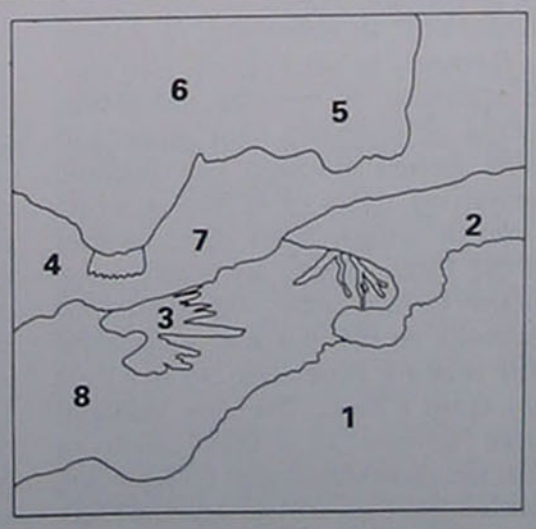
3. Binoculars of 7×50 magnification are useful for spotting birds and marine mammals. Tuck them inside your jacket when not in use.

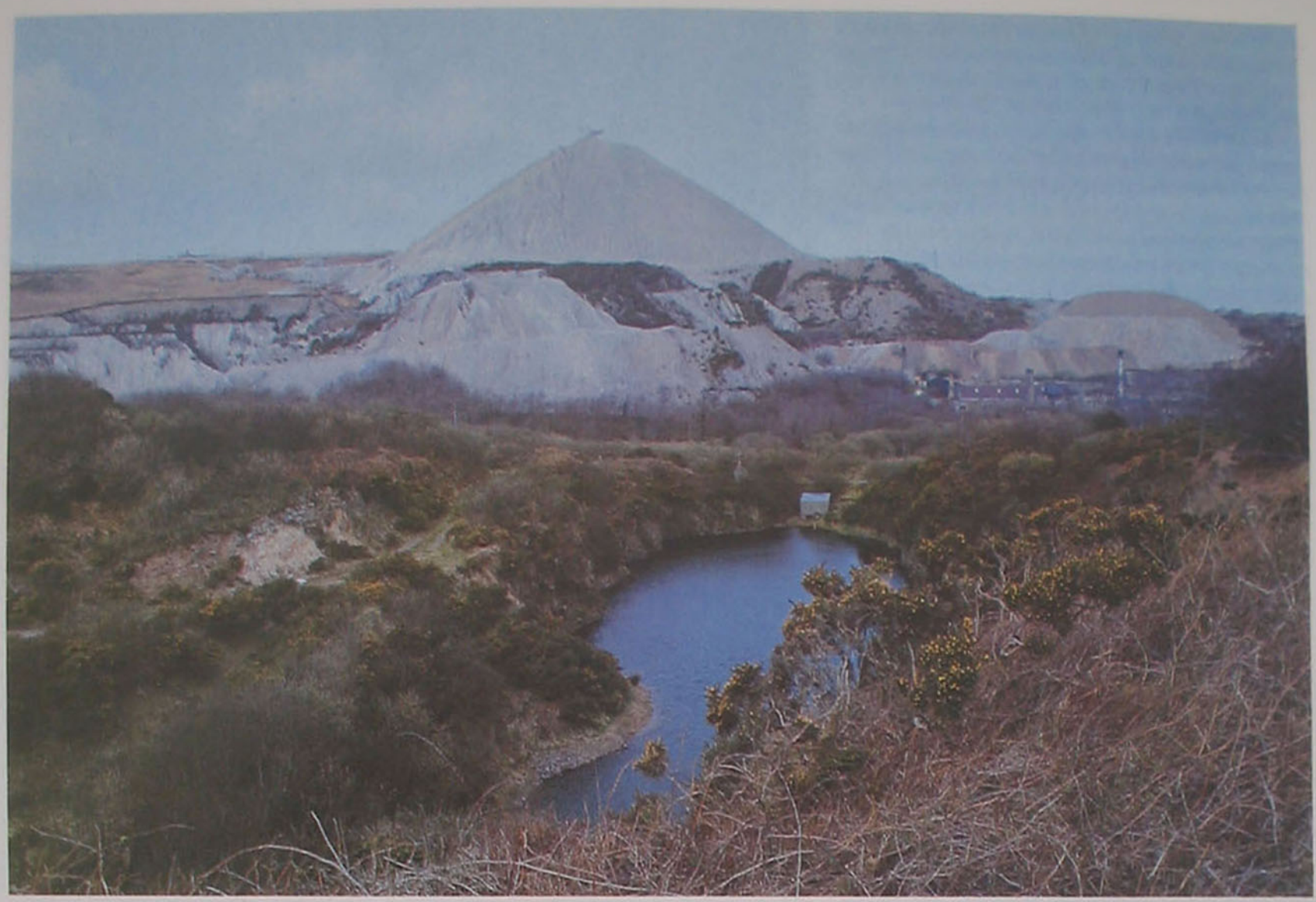
4. Useful extras: a hand lens, plastic dishes for examining small finds, a field guide to the seashore, and sunglasses.

Looking at life in a rock pool

A few seaweed-covered rocks which are beginning to be covered by the incoming tide shelter a wealth of life when you know where to look.

Green seaweeds are abundant here – they appear different when dry (**1**), wet (**2**) or submerged (**3**). Look among the fronds for small invertebrates such as worms or crabs. Overhangs (**4**) hide anemones, sponges and other seaweeds. Limpets and barnacles cling to the larger rocks (**5**), while crevices (**6**) retain moisture and shelter small molluscs and sea slaters. The water beneath the overhang (**7**) may house a small fish, prawn or crab. Turn the stones (**8**) carefully to reveal other small creatures.





THE RECLAIMING OF THE CORNISH ALPS

To a large extent the China clay waste tips of Cornwall remain a man-made wilderness, defying the natural forces of regeneration, but great progress is being made towards re-moulding them – perhaps into the 'Cornish Downs' of the future.

Above: After 150 years of intensive workings, the glistening white clay tips – known as the 'Cornish Alps' – have become a familiar sight along the south-west coast. Around St Austell, the heart of China clay country, some 67sq km (26sq miles) of scarred pit workings erupt incongruously from the gently pastoral landscape. Dotted about this bizarre scene, mica lagoons glint in the sunlight, while in the beds of derelict pits lie deep jade green ponds, some now stocked with trout.

Millions of years ago, much of the earth's crust in Britain was, as elsewhere, in a state of volcanic ferment. In the region that was, after much upheaval, to become the south-west peninsula of England, hot gases and molten fluids pulsed through the granitic rock, decomposing parts of it into a white substance much softer than the mother granite. In the 18th century an enterprising man, William Cookworthy, demonstrated that the deposits so formed had wonderful potential for making porcelain, an art then known only from China. The raw material thus became known as China clay, or 'kaolin' after the mountain ridge of Kao-ling in China where the clay was first unearthed.

Since Cookworthy's discovery, China clay has become a big industry, serving the paper, pharmaceutical, plastics, paints and rubber goods trades, to name only the most important.

Like coal, iron ore, or any other mineral won wholesale from the soil, China clay extraction produces a vast excess of waste material. After peeling off the 'overburden' of earth, rock, and peat, pressurised water jets blast the pit below, yielding a slurry of China clay and coarse quartz sand. The valuable clay is creamed off through a series of settling tanks. The flaky mica waste is deposited in lagoons, while the mass of unwanted sand is discarded in tips. After 150 years of intensive workings, the tips – known locally as the 'Cornish Alps' – have multiplied to become a familiar sight to travellers along the south-west coast, along with the glinting mica lagoons, and the jade green ponds at the bottom of the pits.

Natural regeneration In earlier times the extraction process was less thorough than it is now, and the tips, though essentially sandy gravel laced with mica, contained some fertile topsoil. Even so, this shifting substrate, with many properties akin to arid desert, presented a formidable challenge to plant pioneers. Only by degrees did a simple community of plants, normally more at home on acid heath, gain a tenuous foothold on the tips. Ling, bell heather and bilberry helped to bind the loose

sand together, creating a firmer anchorage for more robust types such as bracken, hard fern, polypody, foxglove and bramble.

While the lack of organic matter in the soil, particularly nitrogen, proved a barrier to many plant forms, it presented less of a handicap to certain leguminous species, notably gorse, which remains the only survivor on many of the more eroded slopes. In places, however, another much less familiar leguminous species flourishes – the handsome tree lupin (*Lupinus arboreus*), which can reach 3m (10ft) in height. Introduced into Britain from California in 1793, the tree lupin's stronghold is the sandy coast of East Anglia, but it evidently relishes the clay waste of Cornwall.

Like other leguminous plants gorse and tree lupin have nodules on their roots which contain a specialised strain of bacteria capable of 'fixing' nitrogen from the air, and using it to make proteins, some of which build plant tissue. Most, however, is released to the soil when the plant dies, greatly enhancing its fertility. On the clay tips the growth of grasses around the base of isolated lupin bushes testifies to the lupin's value as a nitrogen producer.

In the later stages of plant succession, more demanding shrubs and even trees can establish themselves in the tilth created by these forerunners. The acid-loving rhododendron grows well here, while the wetter pans between the tips support horsetails and goat willow. The climax to this painfully slow transformation seems to be oak, though as yet there is no continuous woodland.

Birds on the tips Just as the old waste tips drew their plant pioneers, in the main, from the surrounding countryside, so they have inherited a small community of local bird species. Carrion crows and magpies sally forth from the hedgerows to forage on the scrubby slopes, while kestrels and buzzards are attracted by vole and rabbit prey. Others seek a more permanent home here: skylarks and meadow pipits nest in the tussocky grass while jackdaws inhabit the chimneys and walls of long-abandoned steam engine houses.

Man-made regeneration However hard nature has tried to invade and mellow the old tips, its regenerative powers are limited in such sterile conditions and the end result is scarcely very attractive or useful to man. Faced with an increasing output of clay waste, and amid a growing public awareness of environmental issues, the early 1970s saw the parent company (English China Clays) launch an imaginative scheme to reclaim – by vegetating – the more recent tips.

Without the help of man, these tips, being almost pure sand (so efficient is modern extraction), threatened to resist even the frugal colonization witnessed on the old tips. If stabilised and grassed over, these new tips would cease to be a landslide hazard or a source of wind-blown sand, but could instead offer the community a valuable recompense for the precious pastoral land steadily being bulldozed under.

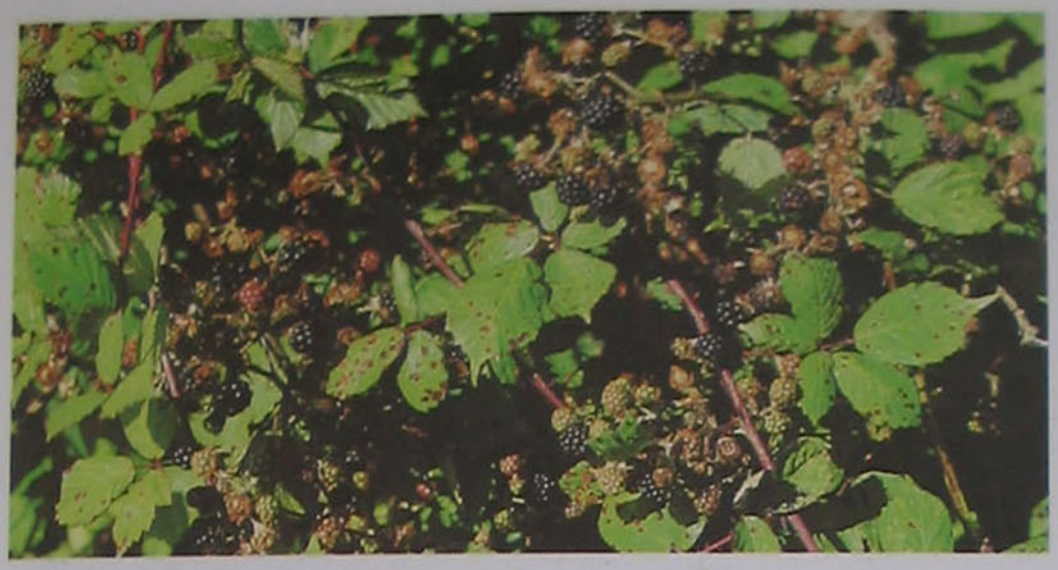
The challenge of reclamation was formidable, involving much trial and error by botanists from Liverpool University. Early success, however, was achieved with the drained mica lagoons which, being level, did not suffer the erosion experienced by the slopes. Once fertility in the lagoon areas was boosted with fertilisers, belts of elder and alder, holly, laurel, sycamore, oak, willow and spruce were soon thriving.

Hydroseeding Initial attempts at fertilising and seeding the steep-sided tips failed when natural run-off rapidly leached the goodness, especially the life-giving nitrogen, out of the

Above: The lack of organic matter on the clay tips has proved a barrier to many plants, but some of the leguminous species, such as this tree lupin, are early colonizers on the tips because the nodules on their roots 'fix' nitrogen from the air and help them to grow on barren land.

Right: Once regeneration starts on the clay tips animals appear. Such birds as this magpie come to the scrubby slopes to forage for snails, worms and insects.

Above: An old clay tip near St Austell – natural regeneration is well under way here and the unsightly tip is gradually being submerged in a tide of green plants. Plant species such as gorse are pioneer colonizers in this process, followed by acid-loving species such as rhododendron. Such regeneration is, however, painfully slow and does not necessarily end with an attractive-looking site. It is necessary for man to step in if the process is to be hastened at all.



Above: Once a firm anchorage has been established by gorse, bell heather and bilberry on the clay tips, such robust species as bramble can take hold. The blackberry fruits then attract a host of insects and birds.

porous sand. In much the same way as nature, left to her own devices, had done, this problem was partly overcome by sowing nitrogen-fixing clover and lupins. These, along with various grasses, have produced a fine sward on selected tips, doubtless helped by the modern practice of building lower, plateau-style tips in place of the high, conical peaks of old.

The most precipitous slopes, however, proved impossible to tame until 'hydroseeding' was applied. In this technique, the ground is sprayed with a paste containing the chosen seeds together with all the nutrients they need to germinate successfully. The best recipe turned out to be a wet mulch of seed, fertiliser, lime and peat, plus a rubbery solution to act as a binding agent.

The solution–Soay sheep Having manufactured a pasture of sorts, the China clay company then resorted to much more traditional methods of maintaining and managing it. The quickest way to improve a pasture is to stock it with grazing animals. This stimulates growth of herbs while preventing the more rampant scrub species from gaining ground. Above all, livestock gives soil the quickest and most balanced injection of fertiliser it can possibly have, in the shape of manure. The company sought a breed of animal that could cope with less than ideal grazing (much of it difficult of access), and that would be light-footed enough not to undo the good work of the botanists.

The unlikely candidate arrived at for this delicate task was the Soay sheep, the most primitive breed in Europe. The Soay is a small, dark brown sheep, with short curly wool, and goat-like agility and sure-footedness. Its ability to survive under stringent conditions, whether parched Mediterranean mountainsides or salt-burned Atlantic cliff-tops, seems to suit it perfectly to life on the reclaimed waste tips.

The first Soays were brought to mainland Britain from St Kilda in 1910 by the Duchess of Bedford, and from this nucleus several flocks, registered by the Rare Breeds Survival Trust, have been established. The English China Clay Company was able to purchase five small flocks, each of about 20 animals.

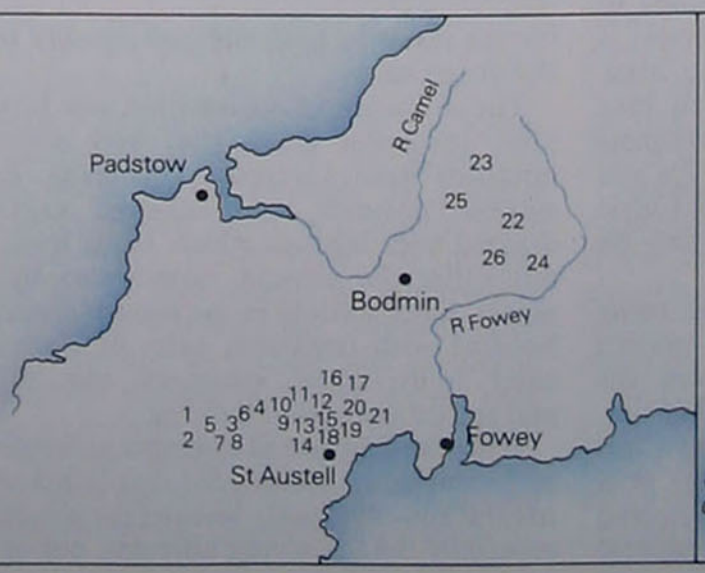
The Soay, still a wild breed in many ways, has proved to be a tricky customer on the man-made swards, often outwitting the traditional strategy of shepherd and dog. At round-ups the flock is more likely to scatter than bunch, while wayward individuals will readily hide to avoid capture. In an essentially industrial region, where free-ranging animals could be troublesome, the sheep also need to be contained like conventional livestock.

Despite these shortcomings, the company's original faith in the Soay has proved well founded, and the 250 or so head of stock are now making a major contribution to the reclamation scheme.

Below: Soay sheep were found to be ideal for grazing the rough pastures created by 'hydroseeding'. They can thrive on poor grass that is difficult of access, and are light-footed enough not to damage the land.

China clay in Cornwall

1 Wheal Remfry; **2** Fal Valley & Melbur; **3** Treviscoe; **4** Hendra; **5** Virginia; **6** Rostowrack; **7** Kernick; **8** Trethosa & Goonvean; **9** Dubbers; **10** Dorothy; **11** Littlejohns; **12** Gunheath & Hensbarrow; **13** Longstone & Great Longstone; **14** Blackpool; **15** Greensplat; **16** Goonbarrow; **17** Rocks; **18** Lower Ninestones; **19** Great Treverbyn, Carclaze & West Carclaze; **20** Treskilling; **21** Bodelva; **22** Hawkstor; **23** Stannon; **24** Park; **25** Wenford; **26** Moorswater.



Most of the clay pits still working are centred on St Austell, but there are a few on Bodmin. The names are highly traditional, like those of Cornish tin mines.

COMMON SEALS

In spite of their name, common seals are, in fact, far less common than grey seals. They live in sheltered estuaries and long sea lochs.

The common seal is the smaller of the two species of seal that breed in Britain. Its North American name, harbour seal, is much more appropriate since it is mainly an animal of sheltered waters. It is nearly always found in estuaries such as the Wash and the Moray Firth, or far into the long sea lochs of the west coast of Scotland, such as Loch Sunart and Loch Linnhe.

Single pup The common seal gives birth to its single pup in late June or July; twins are rare. The birth takes place on a tidal rock platform or sandbank at low tide, or occasionally in water. The pup is well developed and relatively independent from birth, and as the tide rises and covers the birth site both mother and pup take to the sea and swim until the next low tide.

The grey seal is born with a white pup coat; although the common seal does have this white coat at an earlier stage in its development, it is shed while the unborn pup is still in the uterus. The moulted remains of the lanugo, as this coat is called, are expelled with the foetal membranes at birth and can often be found lying on the sand at breeding sites in midsummer. Occasionally a pup is born before the lanugo has moulted, but it soon falls out to reveal the normal coat underneath.

The mother is attentive to her offspring and ushers it to the safety of deep water if danger threatens. During the first few hours after its birth the pup can swim, although not very well, and it has some difficulty with diving. If the pup is very young and cannot easily swim and dive on its own, the mother surfaces alongside and then dives to the safety of deep water with her pup firmly clasped in her fore flippers.

Suckling lasts two or three weeks but after that pups and adults often remain together on the 'haul-out' site. Mating occurs in early autumn and, in contrast to grey seals, always takes place in the sea.

Above: Common seals hauled out of the sea on the rocks and basking in the sun.

COMMON SEAL (*Phoca vitulina*). Also known as harbour or black seal.
Weight of male 100kg (220lb). Female 90kg (200lb).
Length of male 175cm (68in). Female 155cm (61in).
Colour steely grey-black with dense spotting.
Breeding season young born June and July.
Gestation about 9 months after a period of suspended development.
No of young (pups) 1.
Lifespan of male, 20 years, female 34 years.
Food fishes, shellfishes and invertebrates.
Predators man, killer whales.
Distribution coasts of Britain and Ireland. Main breeding sites east coast of England (Wash), west coast of Scotland and most of western and northern isles.

Telling seals apart

Above: The common seal is smaller than the grey seal but it is not easy to tell the two species apart. In the water, when only the head is visible, the common seal shows a more rounded, dog-like head. The grey seal has a larger head with a much flatter profile. The common seal's coat is spotted rather than blotchy, with the spots rather more dense on the back than on the underside. The colour varies from a muddy brown through various shades of grey to a beautiful steely grey-black, depending on whether the animal is wet or dry, and the state of moult. The newly moulted coat, acquired at the end of summer, is bright in colour, but this then fades as the year progresses and ends up a dull, lifeless matt brown.
The nostril openings of the common seal (left) almost meet at their lower end, forming a V; those of the grey seal are more widely spaced, and are usually described as being like the outer arms of the letter W.

Protection Grey seals have been protected during their breeding season ever since the first Grey Seal Act of 1914, but it was not until 1970 that the Conservation of Seals Act introduced measures for the conservation of both species. Since then both species have been protected during their breeding seasons, which in the case of the common seal extends from June to August.

During the 1960s much seal hunting took place, especially for common seal pups, in both the Shetland Islands and in the Wash. Hunters were encouraged by the high prices offered by the fur trade for common seal pup skins. Each year in Shetland almost all the pups were killed by hunters, and some adults were also killed. The common seal population started to decline quickly and in some areas where they had been abundant there was not a seal to be seen.

The 1970 Act imposed a total ban on hunting, and since then the number of seals has increased so they are returning to their traditional haunts. The present population in the British Isles is about 20,000 animals compared to more than 80,000 grey seals.

Distribution Common seals are found mainly around the Scottish coast and islands, especially in more sheltered parts of the west coast and northern isles. Seals in the Moray and Beauly Firths are found on the extensive sandbanks in these estuaries, but at most other sites they are seen on rocky islands or seaweed covered rocks just offshore.

Almost all Scottish islands have some groups of resident common seals. They can often be seen from the road and, in one place near Oban, from the train. In England they are mainly concentrated in the Wash where about 6000 are resident. Numbers there have remained fairly constant in the past 30 years, but just across the North Sea in Holland they have declined drastically over this period.

Dutch seals Around 1940 there were about 2700 common seals living in the Dutch part of the Waddensea, but due to the pressures of hunting and, more recently, human disturbance and pollution, there are now fewer than 700 animals. Pollution from DDT and PCB (a by-product of the plastics industry) which pour into the Waddensea from rivers such as the Rhine, Ems and Elbe, is thought to be one cause of seals being less successful in breeding. Disturbance by people walking on the sands, passing by in boats, or even flying over the area may interrupt the suckling and lead to pups being abandoned or separated from their mothers. Disturbance may also be a contributory cause of large septic patches seen on the bellies of many seals. This is because the raw umbilicus of the very young pup is easily infected, and the constant disturbance means that the seals are continually dragging themselves up and down the sandbanks, with the result that the wound does not get a chance to heal, and so may persist for many years. This is a particularly severe problem in Dutch waters, but it is also seen on British seals.

Seals on view Common seals are usually seen on a sandbank or rocky island which will offer them a quick escape into deep water, so they are often difficult to approach closely. However, in some places they become quite used to visitors and may lie quite close to

Common seals in inland waters

Probably as a result of their preference for sheltered waters, common seals are often found in inland waters. There are many records of them travelling a long way up rivers, and into freshwater lochs in Scotland. Common seals have been seen as far up the River Thames as Teddington, and they travel up the Great Ouse from the Wash right into the heart of Cambridgeshire. The first barrier to their progress is Brownshill Staunch, about ten miles north-west of Cambridge, but they pass this easily if the water levels are right. About ten years ago one common seal travelled right upstream and eventually gave birth to a pup near St Ives, which is over 45 miles from the nearest seal-inhabited sandbank in the Wash. Very often these inland excursions are in pursuit of salmon or trout which are themselves migrating upstream. The seals just follow their meal up the river—but such behaviour does not endear them to anglers on the river bank who fear their sport will be spoilt.

public roads, or even in view of inhabited houses. Some of the most popular places where common seals can be seen are Blakeney and Hunstanton in Norfolk, Dunvegan in Skye, and at Oban on the west coast of Scotland.

At these places regular boat trips are made to take visitors to see the seals, and at many of these sites the animals become accustomed to the regular boatmen and can be approached very closely. However the arrival of a strange boat will cause them to slip away to the safety of deep water nearby. Taking advantage of one of these trips to 'Seal Island' is usually the best way to get a good view of common seals.

Most common seal sites are submerged at high tide. Often the animals can be seen, apparently lying on the surface of the sea with their heads and tails raised high to keep them clear of the water. As the tide rises further, they are floated off their perches and have to swim around until the tide falls again and the rocks are exposed.

Common seals, unlike their noisy relatives the grey seals, are rather quiet animals. Usually you hear the pups calling to their mothers, mostly as a means of keeping in contact while they are swimming over the high tide period. Adults do call occasionally, particularly in early autumn at the time of mating, but they make none of the raucous noise associated with a breeding colony of grey seals.

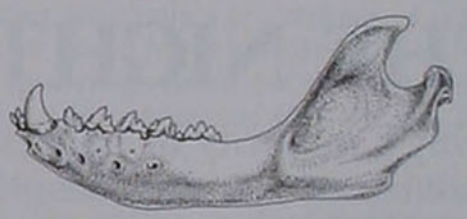
Feeding Common seals feed on a wide variety of fishes which include herring, mackerel, sea trout, skate, cod, plaice and sand eels, and on cockles, mussels, shrimps, squid and even small crabs. They appear to have no problems in dealing with shellfish, partly due to their strong and complex teeth – another feature that distinguishes them from grey seals.

Seals and man Particularly in areas where seals are much disturbed, the newly born pups may be separated from their mothers and often these 'lost' seals are rescued by people walking the shores. In some places, such as Skegness, special seal nurseries have been established to care for these orphans.

Above: A common seal with its pup. Pups weigh about 10kg (25lbs) at birth and have an adult type of coat, quite unlike grey seals which are born with a white pup coat. Common seals are rather more aquatic than grey seals, and do not need to spend three weeks ashore while rearing their pups. Quite often mother and pups are seen swimming in close company, the pup following just behind the mother and partly supported on her back. Unlike grey seals, common seals do not have complex social behaviour at pupping time and they maintain their daily routine in the same site all year.

Below: A common seal pup at Loch Linnhe on the west coast of Scotland.

Seal teeth



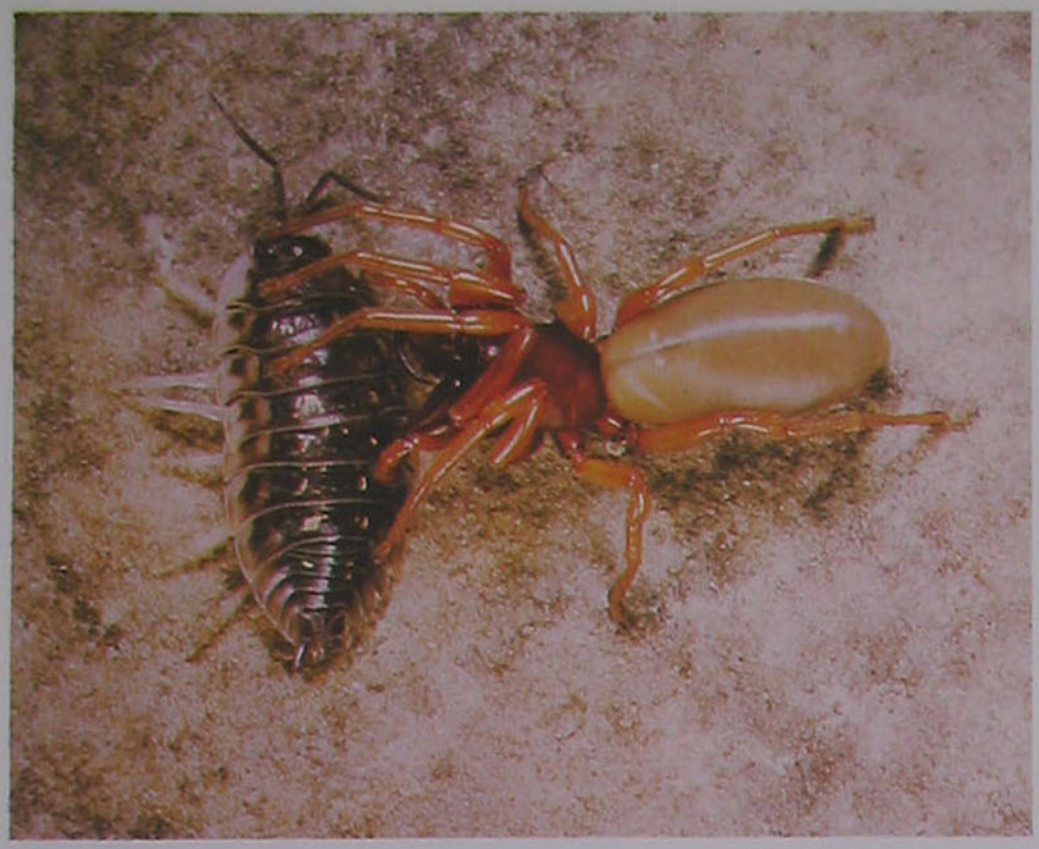
Grey seals have rather simple conical teeth (bottom), but the teeth of common seals (top) have three very distinct cusps for crunching food.

In Germany and Holland such places provide a valuable service by returning these pups to the wild, which is important where the seal population is small and declining.

Common seals can be playful in the water and may race across a bay, leaping clear of the water like dolphins. In autumn this behaviour is often associated with mating, but it happens at all times of the year.

Scientists have tagged seal pups in the Wash and some of these animals have been seen later on the Dutch and French coasts, but there appears to be little travel in the opposite direction, probably because there are relatively few seals on the other side of the North Sea.

The common seal population on the Dutch coast now appears to have stabilised, but grey seals are known only as rare visitors to these waters.



Above: Most spiders reject woodlice as prey, probably because they find it difficult to penetrate the tough chitin of the outer casing—especially if the woodlouse rolls into a ball when attacked. *Dysdera crocata,* however, has very large jaws which enable it to grip and penetrate a woodlouse's defences. It turns the woodlouse on to its side and then inserts its fangs.

HUNTERS OF THE NIGHT

Only a minority of spiders specialise in hunting at night, spending the daytime in a secure hiding place and emerging as night falls to hunt for their prey.

Most night-hunting spiders belong to the families Gnaphosidae, Clubionidae and Dysderidae. Although they may be a little dull in appearance, they have a fighting reputation.

Typical night-hunters have moderately long legs and slim, elongated bodies that allow them to pass through tight spaces. With few exceptions, their coloration is not bright and decorative patterns or markings are usually absent. There may be six or eight eyes which are always small and of approximately equal size. They probably do no more than distinguish night from day—sight is much less important than tactile and chemotactic (chemical recognition) senses in the detection of prey and mates. Night-hunters are uncertain of objects, including prospective mates, until they actually touch them and so, as they advance stealthily, the front legs test the terrain constantly. If the legs do come into contact with suitable prey, one touch seems to be enough for immediate recognition and the prey is attacked immediately.

Night-hunting spiders do not spin webs; instead, most species construct silken, tube-like retreats in which they can pass the day, moult, mate or lay eggs.

Aggressive night-hunters Two of the most familiar species of night-hunting spiders belong to the family Gnaphosidae, and both are quite common around houses and sheds. The first, *Herpyllus blackwalli*, whose body measures up to 11mm ($\frac{3}{7}$in) long, can often be found hunting in rooms at night. It is one of the species that habitually falls into baths and sinks, cannot climb out, and is discovered there in the morning.

In spite of the generally dry atmosphere of houses, *Herpyllus* can survive without water for months. It is one of the few spiders that consumes dead insects—butterfly collectors have discovered this to their cost after leaving specimens on their setting boards overnight.

Herpyllus is known as the 'mouse spider' because of its silky grey abdomen and narrow, rather pointed, cephalothorax. It is rather fierce to deserve the name 'mouse', and if attacked has an effective form of defence. It lifts its abdomen high into the air to trail a wide band of sticky silk from its spinnerets, so that any pursuer is likely to become entangled in it.

During mating, the predatory instinct is not entirely subdued and some violent sparring is the nearest approach to any form of courtship. Copulation proceeds once the female quietens down and although the male is almost as big as the female, he nevertheless departs quickly when it is over. The tough white egg sacs containing about a dozen eggs may be found cemented into crevices during the summer.

The second gnaphosid species, *Drassodes lapidosus*, is similar to *Herpyllus* but larger, measuring up to 15mm ($\frac{3}{5}$in) or even, exceptionally, 22mm ($\frac{9}{10}$in). It is particularly adept in its aggressive use of silk bands to catch large insects and in fighting and defeating most other spiders.

Drassodes may be found in its silken retreat under stones and debris throughout the country, but it is especially common in suburban and coastal areas. At night, it may be seen in the light of a torch moving stealthily along a fence or over the walls of a shed.

Below: *Drassodes lapidosus* seizes small prey in its jaws, but swiftly immobilises larger prey by encircling them with silk threads which are trailed from its long spinnerets. At the same time, it delivers bites to its victim's body.

The dangers of mating The male *Drassodes*, in common with other short-sighted night-hunting spiders, relies on his chemotactic sense to alert him to the presence of a female in the vicinity. The male is not as large as the female and during mating he runs the risk of being killed and eaten.

To minimise this danger, the male matures early, in April or May, and builds his retreat adjacent to that of an immature female. Here he prepares to wait until she moults for the last time. While she is in this temporarily weak state, he begins to vibrate the partition between them, and then enters unless strongly repelled.

After mating, the female lays up to 100 eggs in thick, white sacs, of which as many as a dozen are deposited inside her chamber during June and July to hatch later in the summer.

Woodlouse predator A member of the family Dysderidae, *Dysdera crocata*, which measures 10-15mm ($\frac{2}{5}$-$\frac{3}{5}$in) long, is rather sinister in appearance, its hairless creamy abdomen contrasting with its dark red cephalothorax and pale orange legs. Its fierce appearance is enhanced by the size of its chelicerae, or jaws, and it is undoubtedly capable of biting humans. However, the large chelicerae are an adaptation to its unusual diet of woodlice – hence it is sometimes known as the woodlouse spider.

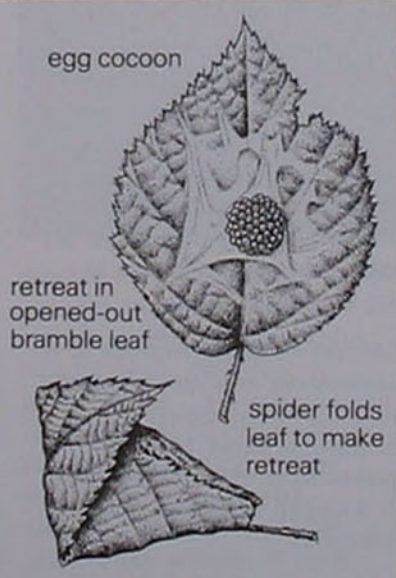
Mating with *Dysdera* is a rather casual affair which may take place at any time of the year, whenever the sexes meet. The male holds the female's chelicerae apart with his own to prevent being bitten if she should prove unwilling. If she is receptive, she raises her body and allows him to move beneath her to insert both palps together into her genital opening.

The female may store sperm within her body for up to 18 months, laying eggs in May or June. A bundle of about 60 eggs, held together with only a few strands of silk, may then be found in the retreat with the female. The spiderlings hatch out within a couple of weeks, and individuals may live for four to five years.

Above: The large black *Herpyllus blackwalli* searches at night over walls and floors for insects such as flies, clothes moths and silverfish, but retreats into crevices and behind pictures during the day. A fierce spider, it will readily attack other spiders, like the *Clubiona corticalis* shown here, which is also an inhabitant of houses.

Hide-away spiders

Clubionids are noted for their retreats, or enclosed dwelling places, which they build on a variety of plants. The retreat of *Clubiona reclusa* (right) is woven within a leaf – usually bramble or stinging nettle – which is curled over and held together with many strands of strong, white silk. In May, a female's retreat is often also occupied by a male, waiting for the right moment to mate. Later, 30-60 yellow eggs are laid in a cocoon inside the retreat (shown below).
The mother guards the spiderlings when they hatch in July and stays close by them, even when the nest is opened up.



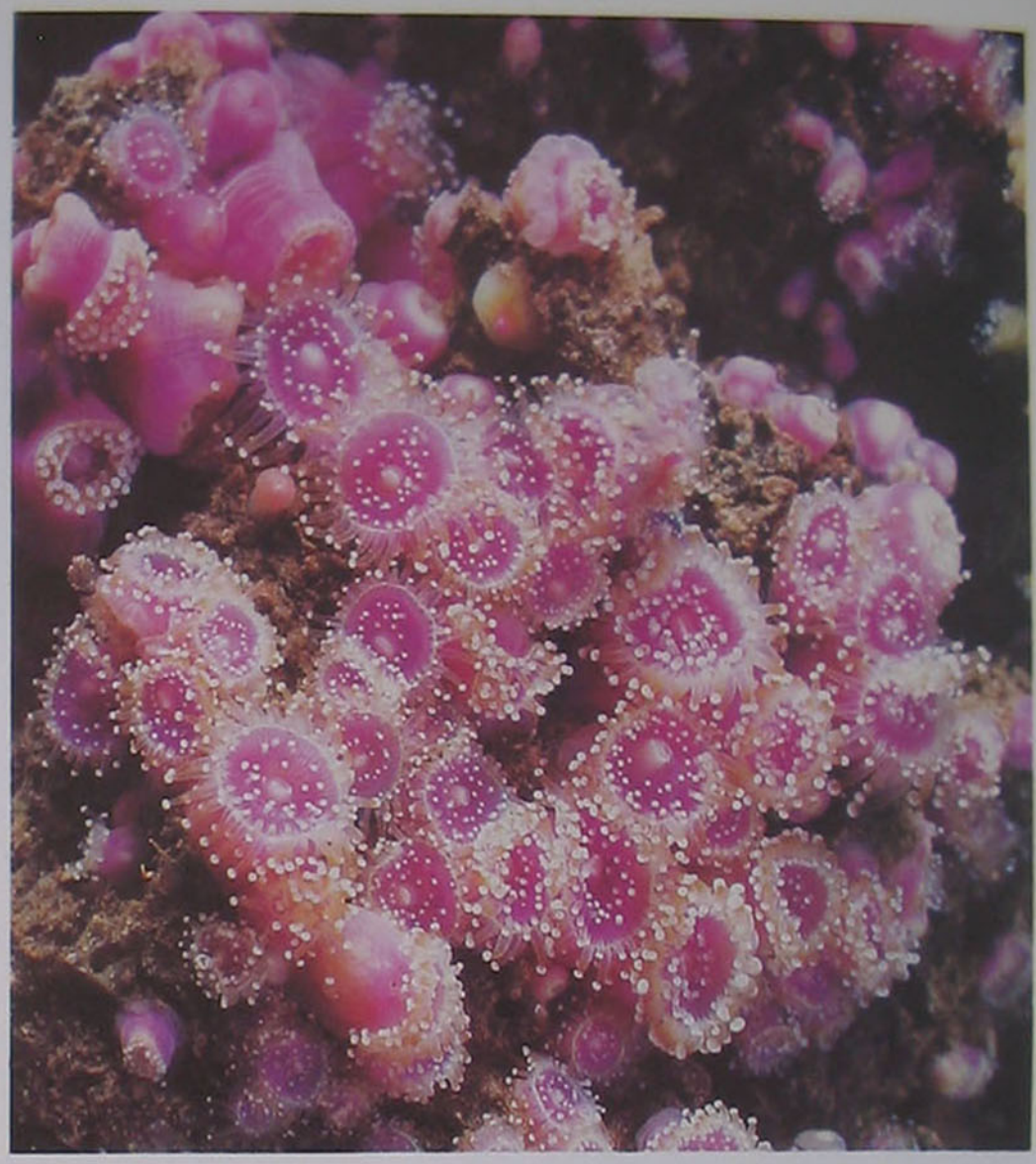
More night-hunters The family Clubionidae is closely related to the Gnaphosidae and members of the two are often confused as the most important distinguishing factor is the relative spacing of the spinnerets. Clubionids include a large number of night-hunting spiders, but these are distinguished more by their habitats than by their individual characteristics. In particular, the genus *Clubiona*, which is widespread and common, can be divided into those that live on foliage and those that live on or near the ground.

Many of the ground-living species are not true night-hunters as they remain active during the day in shady places under debris and beneath thick vegetation. The plant-living species include *Clubiona pallidula* which is found on brambles, *C. brevipes* which is usually found on oak, and *C. subsultans*, a pine-dwelling species. They range in size from 6mm to 11mm ($\frac{1}{3}$in to $\frac{2}{3}$in) and are pale brown in colour, with dark, heavy chelicerae. They have adhesive pads on their feet which help them to run on the underside of leaves.

Tubular retreats are constructed under bark and also inside the rolled leaves of such plants as bramble. These deliberately rolled leaves, stuck down with stiff silk, may be quite noticeable on the bushes. Nests of *C. pallidula* are constructed from grass stems which are turned over and bound together. They are easy to spot in meadows, where they may reach a density of about one to every square metre.

SEA-BED ANEMONES

The sea-bed is home to huge numbers of colourful sea-anemones, some sitting on rocks, others burrowing into the mud, and even a few that live on top of other animals.



If you are fortunate enough to be an underwater diver the range of sea-anemones that you can see is much more varied than it is for someone confined to looking at species on the shore, for there are about 40 species of sea-anemone to be found on the sea-bed around the British Isles.

Anemones that live on the sea-bed have a much less hazardous life than their relatives living on rocks on the shore, since they do not have to withstand the extreme conditions of exposure to the air and the problem of desiccation for several hours each day, nor do they have to face extremes of temperature in summer and winter.

The life-cycle and feeding habits of sea-bed anemones are exactly the same as in the species found on the shore, but their mode of life is often different. Anemones that live on the shore are almost always found growing on rocks. Among the sea-bed species, however, many attach themselves to rocks while others bury themselves in sand or mud and some live on the surfaces of other animals.

On the rocks A sea-bed anemone living on rocks attaches itself by means of an adhesive disc on the bottom of its column. It can move slowly, but tends to pass most of its time in one spot waiting for suitable prey, such as small invertebrates, to come close. When they do, the anemone catches and stuns them with its poisonous tentacles.

A typical species, closely related to the dahlia anemone found on the lower shore, is *Urticina eques*. Indeed, until recently the two were thought to be the same species, but the latter has a less warty column and never has pieces of gravel stuck to it, unlike the dahlia anemone. *Urticina eques* is a cold-water species, and is only just found as far south as the southern coast of Britain. It can grow to a great size, with the column frequently measuring 20cm (8in) across, and is found on the sea-bed as far down as 200m (100 fathoms).

While *Urticina* has fairly stout tentacles, another rock-dwelling species, *Metridium senile*, has a great many very fine tentacles, which give it a feathery appearance – hence it is often known as the feather-duster anemone. *Metridium* uses these tentacles to strain the sea-water for particles of suspended food, so, unlike most anemones, it is not predatory. Specimens of *Metridium* can grow to a length of 30cm (1ft) and vary in colour from white, through orange or pink, to brown.

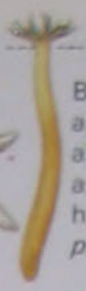
One rock-dwelling species, the jewel anemone (*Corynactis viridis*), seldom exceeds 1cm ($\frac{1}{2}$in) in diameter and looks like a minute version of a typical anemone at first sight. But careful inspection shows that its tentacles are club-tipped, a feature more typical of true corals than of anemones. In fact, the jewel anemone is halfway between the two. It has a number of coral-like features but it lacks the all-important chalky skeleton of this group.

Above: A colony of jewel anemones. This species often reproduces asexually by dividing, and large numbers of identical individuals can be found in the same area. They are usually found below the low tide mark on rock-faces, sometimes in big colonies.

Below: *Peachia hastata* is a burrowing anemone found all around the coast of Britain, in sand, mud or gravel from the lower shore to a depth of 30m (15 fathoms).

Life-styles

Below: A rock-dwelling anemone, *Urticina eques*. This group has a basal disc for clinging on to rocks.



Below: The cloak anemone is almost always found associated with the hermit crab *Pagurus prideauxi*.

Above: In a burrowing anemone, such as *Halcampa chrysanthemum*, only the tentacles appear above ground.

Above: Whereas most shoreline anemones grow on rocks, sea-bed species can also be found burrowing into the substrate or even living in association with another sea-bed animal, such as a hermit crab.

Burrowing anemones These species lack a basal disc on their columns. Instead, the base of the column is usually rounded and called a physa. When the anemone starts to burrow, it flattens its physa and pushes it into the sand. Once the physa has penetrated to a certain depth, the anemone forces water into it from its cavity, causing the physa to expand and act as an anchor while the rest of the anemone's column is pulled into the sand. This operation is then repeated until the anemone reaches the desired depth.

One of the more common burrowing anemones around the coast of Britain is *Edwardsia claparedii*. This species reaches a length of 12cm (5in) and has a translucent pink body. It can occur in great numbers offshore, particularly around south-west Britain. Less common is *Peachia hastata*. This grows to a length of 10cm (4in) and has four adhesive warts on its column.

Another species that seems to burrow is *Sagartiogeton undatus*. It lives on sand or mud and, whenever danger threatens, it retracts its column below the surface. But it is not a true burrower. It is actually a rock-dweller, for it needs a submerged rock or pebble in the sand on which to attach its basal disc. It cannot burrow and maintain its position without such an anchor point.

Anemones in association Besides the rock-dwellers and the burrowers there are also sea-anemones that live in association with other animals. Members of this group are similar to the rock-dwelling species in having a basal disc for attaching themselves to the host animal, but in many cases the disc is wide enough to allow the anemones to wrap themselves right around the host.

One such anemone is the parasitic anemone (*Calliactis parasitica*). The name is a misnomer and comes from the mistaken belief that it is a parasite of the hermit crab *Pagurus bernhardus*, with which it is frequently associated. In fact, both animals benefit from the arrangement. The stinging tentacles of the anemone sitting on the hermit crab's shell give the crab some protection against predators such as octopuses. In return, the anemone is provided with a supply of food from the crab, for hermit crabs are messy feeders. However, both partners can survive without each other.

As the crab grows and seeks a larger shell, the anemones on its old shell often move over on to the new one.

A similar relationship exists between the cloak anemone (*Adamsia carcinopados*) and the hermit crab *Pagurus prideauxi*. The anemone's common name comes from two flap-like growths on either side of its basal disc. When young, the crab occupies a winkle shell. As it grows it acquires a cloak anemone, which grows on its shell, wrapping its flaps around the crab's abdomen. These flaps then slowly secrete a horny substance that builds up to replace the winkle shell as the crab's home. Thus the crab and the horny shell grow together. This frees the hermit from the hazards of finding a new shell at a time when its soft abdomen is particularly vulnerable to predators. In this relationship, neither the anemone nor the crab can survive long without the other.

Above: A group of parasitic anemones growing on a whelk shell inhabited by a hermit crab, *Pagurus bernhardus*. This association is of benefit to both parties, the crab being protected from predators by the stinging tentacles of the anemones which, in turn, feed on bits dropped by the crab. As here, several anemones can be found on one shell.

Right: Often known as the feather-duster anemone because of its appearance, *Metridium senile* is a rock-dwelling anemone with very fine tentacles with which it filters sea-water for particles of food. It occurs in a range of colours (the white and yellow anemones in the background are the same species) and is often found on piers and oil rigs.

FREEDOM OF THE AIR: BIRD FLIGHT

Birds have perfected their powers of flight over aeons of evolution. The result is a series of brilliant wing designs: some that give high speed, some that allow easy control, and others that provide a useful, all-round range of flying skills.

If numbers of species are a worthwhile guide, birds – with over 8000 species that fly compared with 4000 non-flying mammal species – are arguably the most successful class of vertebrates today. Their success is due in large part to the powers of movement, and thus the wide choice of habitat, that flight allows.

How flight works The mechanical problem concerned with flight is how to lift a weight clear of the ground, keep it airborne for a practical time and propel it forwards at the same time. For this, an upward force (lift) and a forward force (propulsion) are required.

A glance at the wing cross-section of a model aircraft shows the solution to this

problem. Rounded and thicker at the front than at the slender 'trailing edge', shallowly convex above and concave below, this is called an aerofoil section. Move an aerofoil section forwards through the air, and it causes air to flow in such a way across its surfaces as to produce lift. The discovery of the aerofoil section enabled man to fly: birds have used it for aeons. The inner portion of a bird's wing, which is anatomically equivalent to the human forearm, has a classic aerofoil section.

The next requirement is propulsion. For this, birds rely on the beating of their wings, powered by the breast muscles (the pectorals) which are highly developed. Propulsion is provided by the outer part of the wing, from the angle (where the front edge bends) to the tip. This part is anatomically equivalent to the human hand, from wrist to fingertips. The ten or twelve long, strong feathers at the end of the wing (the flight feathers) are vitally important and merit their technical name 'primaries'.

Variable geometry The vast majority of aircraft have wings and tail securely fixed in position, and only the provision of flaps and ailerons allows their shape to be altered so that the aircraft is manoeuvrable. Some of the most sophisticated modern fighter planes are famed for their 'variable geometry' but this merely allows the wings to swing in and out from the fuselage. It is easy to see, therefore, how much more manoeuvrable birds are than aircraft, with an almost infinite variety of positions, not just of the wings and tail, but of the parts of the wings and often of the individual feathers.

Take-off and landing To complete their manoeuvrability, birds have to be able to take off and land at will. Many survive precisely because they can do this at a split second's notice, escaping the ever present danger of attacking predators. Taking off requires the maximum output of propelling force (thrust) that the bird is capable of producing.

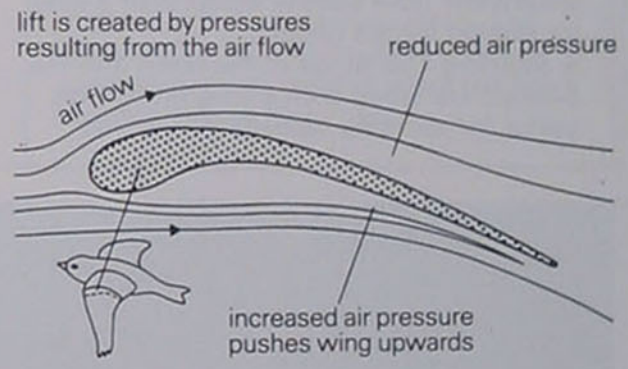
The smaller species are capable of exerting sufficient effort to lift themselves off the ground with no preliminary 'run'. Heavier birds, on the other hand, have to survive without the ability to respond to danger by an instant take-off. Large waterbirds, such as swans and the great northern diver, attain safety by spending much of their time on the open water, far away from the predators on dry land. Their take-off is so difficult that they often have to 'run' some distance across the water surface, and can only occupy stretches of water large enough to allow space for this long take-off.

To land, birds need to 'spill' the lift that their wings and tails have been providing during flight. One way to lose lift is to raise the tail, thus steering into a descent towards the landing place. To halt their flight, birds rear up in mid-air to an upright posture as

Above: Freedom of the air enables these snow geese to choose the best places for feeding and roosting. With advantages like this, birds as a class have evolved twice as many species as mammals.

Below: A bird the size of a heron needs extraordinarily large wings, which it flaps slowly and laboriously. Here it glides for a short distance on outstretched wings, making a 'short hop' to a new spot for fishing.

How an aerofoil works



Five types of bird flight

1 High manoeuvrability The wren can fly neatly among dense undergrowth. The partridge is an expert at the sudden escape flight.

2 General purpose Robins, finches and geese are among the many 'all-rounders'.

3 High performance Long, narrow primaries give the swift and the hobby maximum power with the least air resistance.

4 Gliding The gannet and the Manx shearwater have narrow wings with a long lift section for sea gliding.

5 Soaring The wings of the raven and the buzzard are broad with a long lift section, useful for catching upward air currents.

Above: Brent geese have a 'general purpose' wing layout, but improve their flight efficiency by means of a cunning use of the V pattern. The bird at the front creates turbulence in its wake with the beating of its wings; this turbulence gives extra lift to the birds flying on either flank behind. The lead bird is usually an old and powerful female, who may change places with another as she becomes tired. The less powerful flyers, including youngsters, stay in the arms of the V.

they approach the selected spot. This tilts the wings until they are nearly in a vertical plane, so that they can act as 'brakes', or even beat against the direction of flight. The tail is lowered, also acting as a brake against forward movement.

The hard impact of landing is absorbed by flexible legs and strong muscles, which are attached to the most rigid part of the bird's skeleton – the pelvis, which is fused on to the lower spine for added strength.

Many shapes of wings In the course of evolution, families of birds have developed the capability of flight in a number of different ways to suit the various modes of life they have adopted.

First, there are naturally many birds without a specialised form of flight and these have a 'general purpose' wing layout. In this layout, the lift and power sections of the wing are roughly of equal length. The wing is twice as long as it is wide. Garden birds such as the greenfinch and the robin fit into this category. So, too, do larger birds like geese.

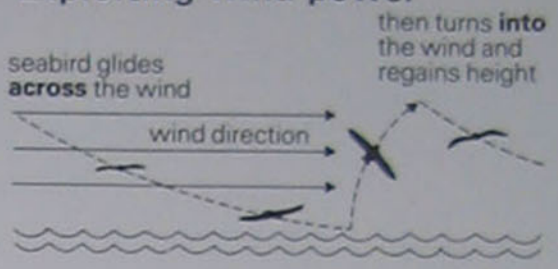
If the 'general purpose' category is placed in the middle of a range of flight styles, one of the extremes on the scale would be 'high manoeuvrability'. Birds in this category have wings with lift and power sections of equal length, but the wing is much rounder in appearance, rather than long, for it is almost as broad at its base as it is long from base to tip. Examples include the game birds, which need fast and almost vertical take-off to escape predators, and birds of thick cover, such as the tiny wren. This wing pattern provides strong propulsion, but the high manoeuvrability results from the broad wing area.

The other extreme consists of the birds that specialise in extra-efficient flight. Among these species, flight is developed to the highest standards of performance. For maximum speed, their wings do not have the same proportions as those of the other categories of birds. The power section of the wing (the primary feathers) is much longer than the lift section – in some cases by as much as a factor of four – and the wing is long and thin.

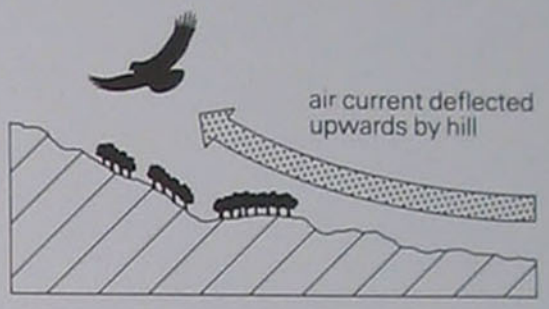
Above: The black primaries of the gannet clearly show the proportions of the wing layout: the white lift section is longer, a good gliding characteristic.

Left: A female golden eagle soars effortlessly. The primary feathers are spread out to obtain maximum advantage from rising air currents; they are also specially shaped to reduce turbulence, helping the eagle to gain speed when gliding downwards, after soaring to its peak.

Exploiting wind power



The seabird takes a shallow downward glide across the wind, then turns into the wind and climbs steeply, until it resumes gliding in its original direction. It thus uses relative wind speeds to power both the climb and control the long, downward glide over the ocean.



Upward air currents are used by ravens, eagles and buzzards. Typical soaring flight is in a slow, circling climb. The birds also exploit thermals, which are upward currents created when the sun's warmth causes air to rise.

The swift is an excellent example.

Two ways of gliding Gliding (in the case of birds) is flying without flapping wings. Two groups of birds are adapted for this type of flight: those that use wind power to travel over the sea (gliding in the common sense of the word) and those that not only glide but also exploit rising air currents to gain height (soaring).

The 'gliding' birds have extremely long and narrow wings, with a lift section either as long as the power section or longer. Most of them are oceanic birds, best exemplified by the albatrosses of the southern hemisphere but represented in British waters by the fulmar, the gannet and the Manx shearwater.

The 'soaring' birds use upcurrents at a ridge of hills or, in warm conditions, columns of rising air called thermals. In warmer countries these currents are the province of the vultures, but in Britain and Ireland the best examples of soaring flight are given by the raven, the buzzard and the golden eagle.

These birds are quite different in silhouette from the seagoing gliders: they too have a lift section as long as the power section or else even longer, but their wings are much broader. Further, the wingtips, rather than being pointed, have a broadly splayed 'fingered' appearance which helps to reduce turbulence. The birds flap slowly and laboriously into the air in wide circles, but once they catch the rising air they soar effortlessly.

Rowing through the air

1 On the downstroke (above) the wings move forward and then, at the bottom of the stroke, push backwards. The feathers are held firmly together, presenting a flat, blade-like surface.
2 On the upstroke (right) the primary feathers twist, like the vanes of a Venetian blind, and thus open a slight space allowing air through; this reduces air resistance to the upstroke.

CONES: SLOW BUT SURE DEVELOPERS

Autumn is the time when most cones ripen from green to brown before releasing their seeds. But this is only the final stage in a long and complicated process of growth and development from a tiny bud first formed as much as four years ago.

Above: A larch in summer with its maturing green cones. These cones were fertilised in the spring of that year. By the autumn they will turn brown and will release their seeds the following spring by opening their cone scales. Once the seeds have dispersed, the old brown cones remain on the tree for a while before falling. In this picture, some old cones that have already released their seeds earlier in the year can still be seen on the tree.

A great many of the world's trees produce their seeds in structures known as cones, so-called because some of the most prominent cones are roughly conical in shape. This huge group of trees–known to us as the conifers–constitutes an order called the Coniferales. As well as bearing cones, all the trees in this order have narrow, needle-like leaves. A few broad-leaved trees seem to have cones, notably alders, but these are not true cones because their structure is entirely different.

Besides liberating the seeds, the cones also bear the ovules and pollen, earlier on in the cycle. In this capacity, they are equivalent to the flowers on a broad-leaved tree, yet the two structures differ in several important respects. Most flowers have petals and sepals, and stigmas to catch the pollen. Plants bearing flowers are called angiosperms (meaning 'seed in a vessel').

Cones, on the other hand, lack petals, sepals and stigmas. The ovules lie at the base of a leaf-like scale instead of being enclosed in an ovary. Hence plants with cones are called gymnosperms (meaning 'naked seed'). All conifers have separate male and female cones, unlike some flowers in which the male and female parts are found on the same structure.

First appearances The very first step in the production of a cone occurs in early spring before the current year's growth has begun. Tiny buds, called bud primordia, start to appear along the shoots. In early summer, the bud primordia begin to develop in one of three possible ways. Some form vegetative buds, which will later develop into next year's shoots, while the others form either male or female cones.

For a long time, the three different types of bud look exactly the same, but after some months they begin to develop into cones or shoots. The male cones consist of stalkless anthers arranged around a central column, each anther containing pollen grains. The female cones consist of scales, also arranged around a central stalk. On the scales sit the ovules. These can best be seen on cypress or juniper cones, where the ovules are just

visible to the naked eye as minute dots. In cones of the pine family, the ovules are partially hidden between the cone scales and bracts. Male cones are usually most abundant on the middle and lower parts of a tree, whereas the female cones are most often seen higher up. This reduces the possibility of a tree pollinating itself by the pollen falling on the female cones below.

Pollination A few weeks after the cones have begun to develop, pollination takes place. The male cones, shaken by the wind, release clouds of bright yellow pollen grains, which are equipped with air sacs to help them float – for cones are pollinated by the wind, not by insects as is the case with most flowers. The pollen grains enter the female cones, which then grow to enclose the pollen inside with the ovules.

In most conifers, pollination takes place in spring or early summer, though some cypresses produce their pollen during winter, and on cedars this occurs during autumn. Once pollination has been effected, the male cones are of no further use and they die off. The female cones, however, continue to grow into mature seed-bearing structures.

Once the pollen is trapped inside the cone it sends out a tube which burrows through the ovule to the egg cell lying inside (as on angiosperms). When the tube reaches the egg cell, fertilisation takes place. On most conifers, fertilisation occurs within a few weeks,

Above: Mature cones on a cedar of Lebanon. All cedars have distinctly barrel-shaped cones borne upright on the branches. The white marks are resin secreted by the cones to seal in the pollen with the ovule after pollination.

Right: Cones of a Douglas fir after the scales have opened out to release the seeds. The three-pronged bracts on each scale once covered the ovules. This is another species that secretes white resin.

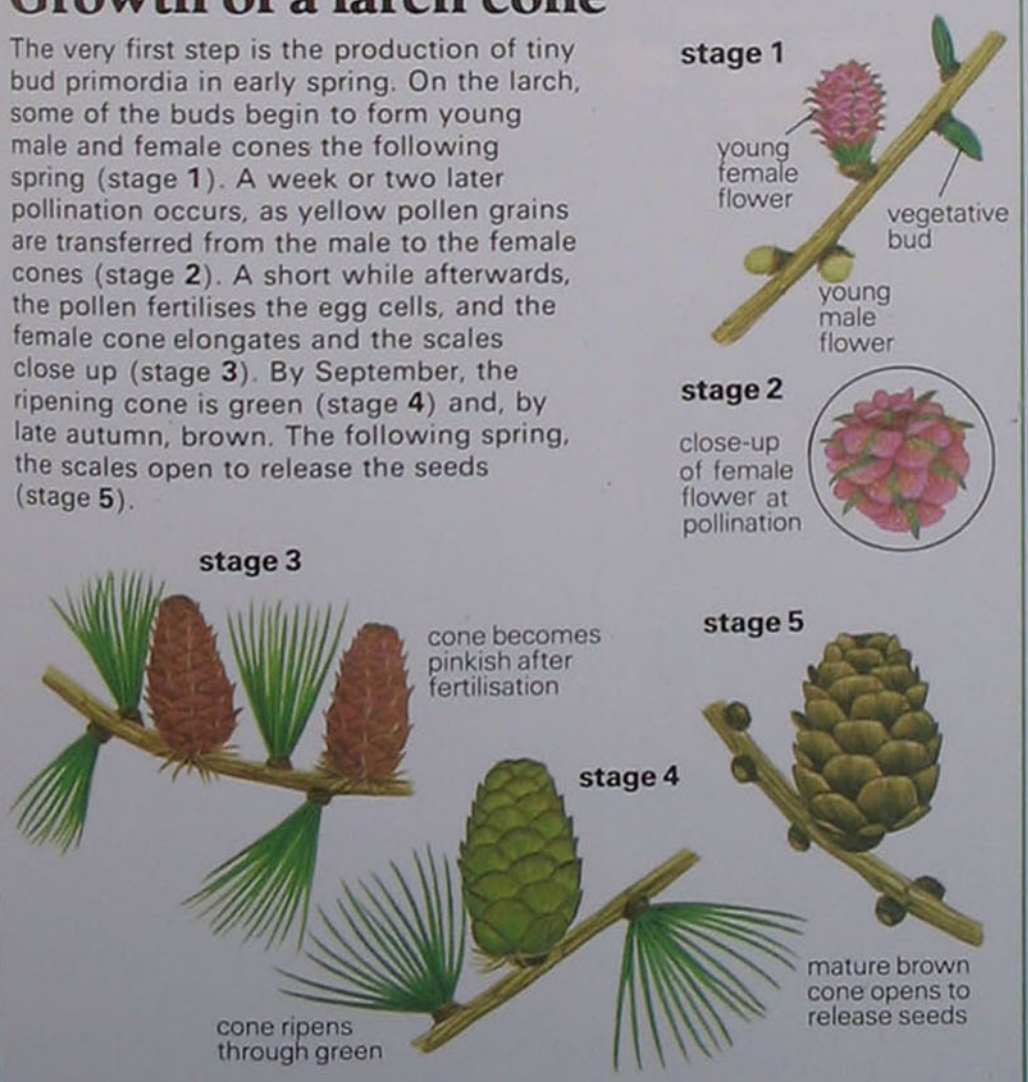
or even days, of pollination, but on pines it takes a whole year for the pollen tube to reach the egg cell.

After fertilisation, the seeds develop. At the same time, the cone is growing and turning green, then brown at maturity. In most species, the female cones are mature by the autumn or winter after pollination. Pines, however, take one or two more years to mature; some cypresses also take two years and the monkey puzzle takes at least that long.

Distributing the seeds Once mature, the final function of the female cone is to release the seeds. Several different methods are used for this. In the most common, the cone scales contract and open out, allowing the seeds to fall. Although the seeds are equipped with small wings, the wind does not carry them further than the spread of the tree. Normally, this method of dispersal occurs in warm dry weather in spring. Spruces, larches, Douglas firs, Scots pine and hemlocks all use this method of distribution, as do members of the redwood family and all but one of the

Growth of a larch cone

The very first step is the production of tiny bud primordia in early spring. On the larch, some of the buds begin to form young male and female cones the following spring (stage **1**). A week or two later pollination occurs, as yellow pollen grains are transferred from the male to the female cones (stage **2**). A short while afterwards, the pollen fertilises the egg cells, and the female cone elongates and the scales close up (stage **3**). By September, the ripening cone is green (stage **4**) and, by late autumn, brown. The following spring, the scales open to release the seeds (stage **5**).



cypress family.

The next commonest method is that used by silver firs, cedars and members of the monkey puzzle family. In these species, the cone disintegrates to scatter the seeds. Silver firs and cedars have winged seeds, which are released with the cone scales, leaving just the central stalk on the tree. In the monkey puzzle, the seeds are large and unwinged; they are gathered and dispersed by animals feeding on them.

A number of pines also have large wingless seeds and rely on animals for their dispersal. Some species in this group release their cones intact. The seeds are then spread by animals foraging among the cones in the forest litter; an example of this group is the Swiss stone pine, also called the arolla pine.

The final method of dispersal is found only in pine trees growing in dry open forests that are prone to fires. In these species, the cones remain intact for years, and only open after a forest fire. The advantage to the species is that the fire removes competing vegetation and provides an excellent seed-bed. Trees with this type of cone are common in western North America and include the Monterey pine, but in Europe only the maritime pine has this characteristic.

Uses of cones As well as being a food source for birds and mammals, conifer seeds have, in some parts of the world, long been an important part of man's diet. For example, South American Indians eat the seeds of the monkey puzzle tree and the Romans used to eat the seeds of the stone pine–indeed they introduced the species to this country for that purpose.

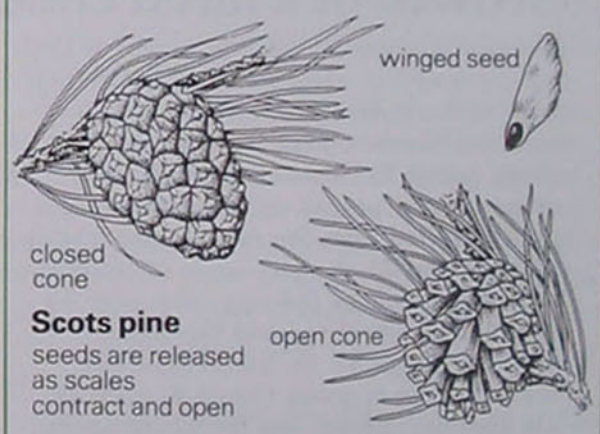
Cones have also been used as a source of fuel and for dyeing; in the Himalayas the Himalayan fir is still used for dyeing. In Britain, however, we neglect our cones, except as Christmas decorations.

Berry-like cones

Juniper and yew are both conifers, yet they do not seem to bear cones. In fact, both do. The juniper berry is a cone in which the scales have fused together and become fleshy and edible. It takes two years to ripen–the berries shown here are a year old. Similarly, on a yew the red fleshy aril is formed out of cone scales.

Above: A maturing cypress cone. The scales on this cone are arranged around a point to form a ball, rather than the more familiar cone-shaped arrangement around a stalk. The immature male (pink) and female (blue) cones are shown below.

Seed-release mechanisms



Scots pine
seeds are released as scales contract and open

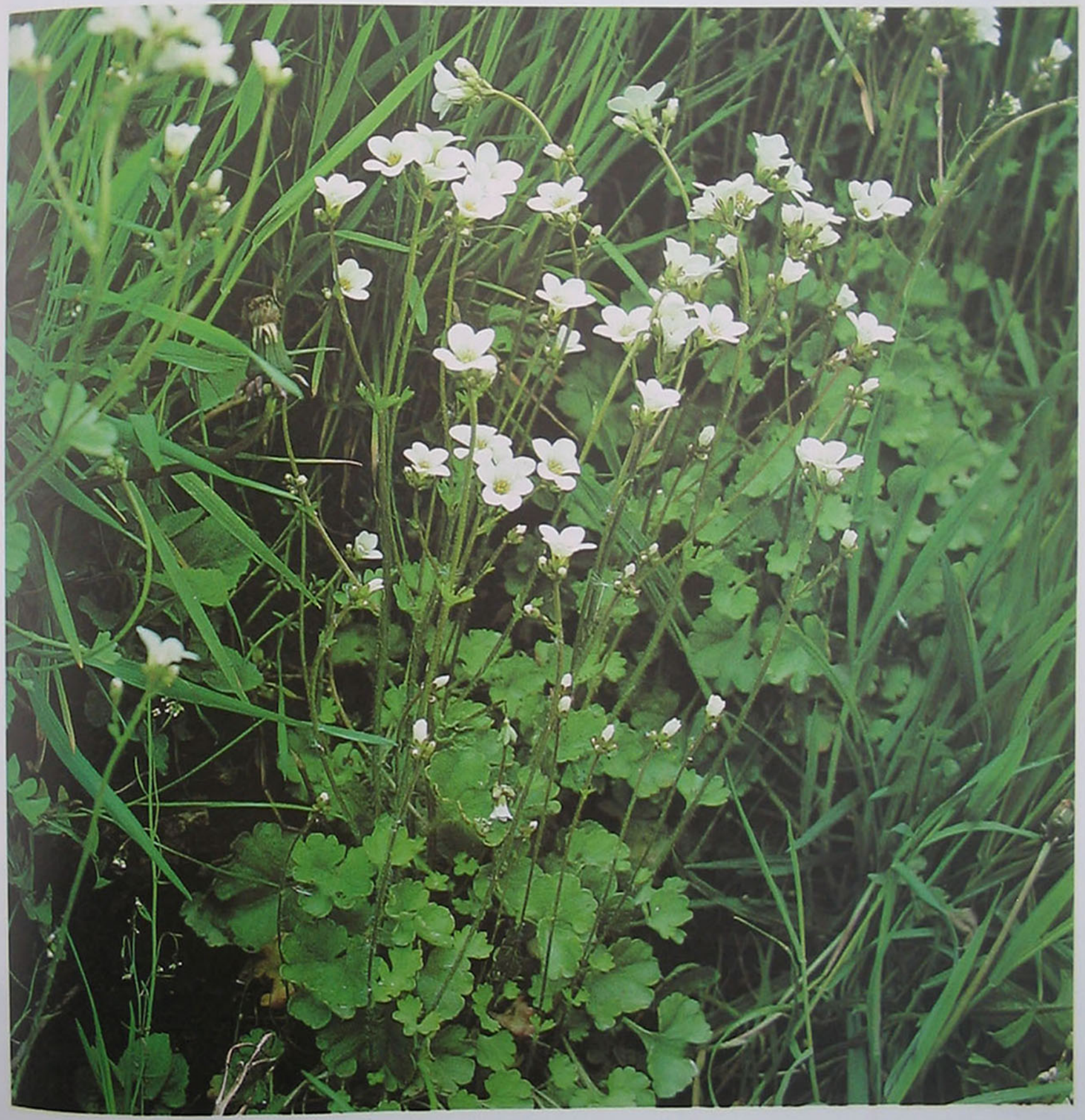
Most conifers release their seeds by contracting and opening out their cone scales. A familiar example of a tree using this mechanism is the Scots pine. The only other common method of releasing seeds is one in which the whole cone distintegrates, leaving just a stalk. The European silver fir uses this method.

REPRODUCING NEW PLANTS FROM OLD

Some species of plants have methods of reproducing that do not involve the uncertainty of flowering, pollination and seed production – they reproduce vegetatively, a process which can involve any one of a number of different parts of the plant.

Most people are familiar with the idea that a flowering plant grows from a seed. When the plant is mature, it produces flowers and, after pollination, more seeds develop to complete the life-cycle. However, as well as reproducing sexually, some species can also produce new plants in a process known as vegetative reproduction. Depending on the species, almost any part of the plant can be involved in vegetative reproduction.

Shooting roots Some species are able to produce buds (known as adventitious buds) directly from their roots, at some distance from the original stem. One such species is the creeping thistle, and it is a common sight to see rows of stems spreading out around the



Above: Silverweed (*Potentilla anserina*) has creeping and rooting flowering stems and can spread quite rapidly to cover large areas with its yellow flowers and silvery leaves.

Previous page: The meadow saxifrage (*Saxifraga granulata*) is not normally thought of as a bulbous species, but at the base of the lower leaves on its flowering stem it produces minute bulbils which are easily broken off and will grow into new plants.

Opposite: A close-up of the gemmae cups of the liverwort *Marchantia polymorpha*, a common species of damp, shady spots. A single raindrop falling into each cup scatters the gemmae, each of which is capable of forming a new plant.

original plant. The shoots produced in this way by woody species are usually called suckers, and they can be seen on blackthorn, and also burnet rose.

Rooting shoots A form of vegetative reproduction that is more immediately apparent involves the stems of a plant. Creeping stems, for instance, frequently root, and each section is capable of independent existence as a new plant. Creeping Jenny and silverweed are examples of plants that spread in this way. In other species, such as dewberry, it is just the tip of the low, hoop-like stem that curves down to the ground and takes root. The following season, new shoots arise from the rooted tip and the cycle is repeated.

Runners and rhizomes Sometimes the stem involved in producing a new plant is different from the normal stems. The familiar woodland wild strawberry has specialised slender stems called runners and a single runner is capable of producing a whole string of new plants.

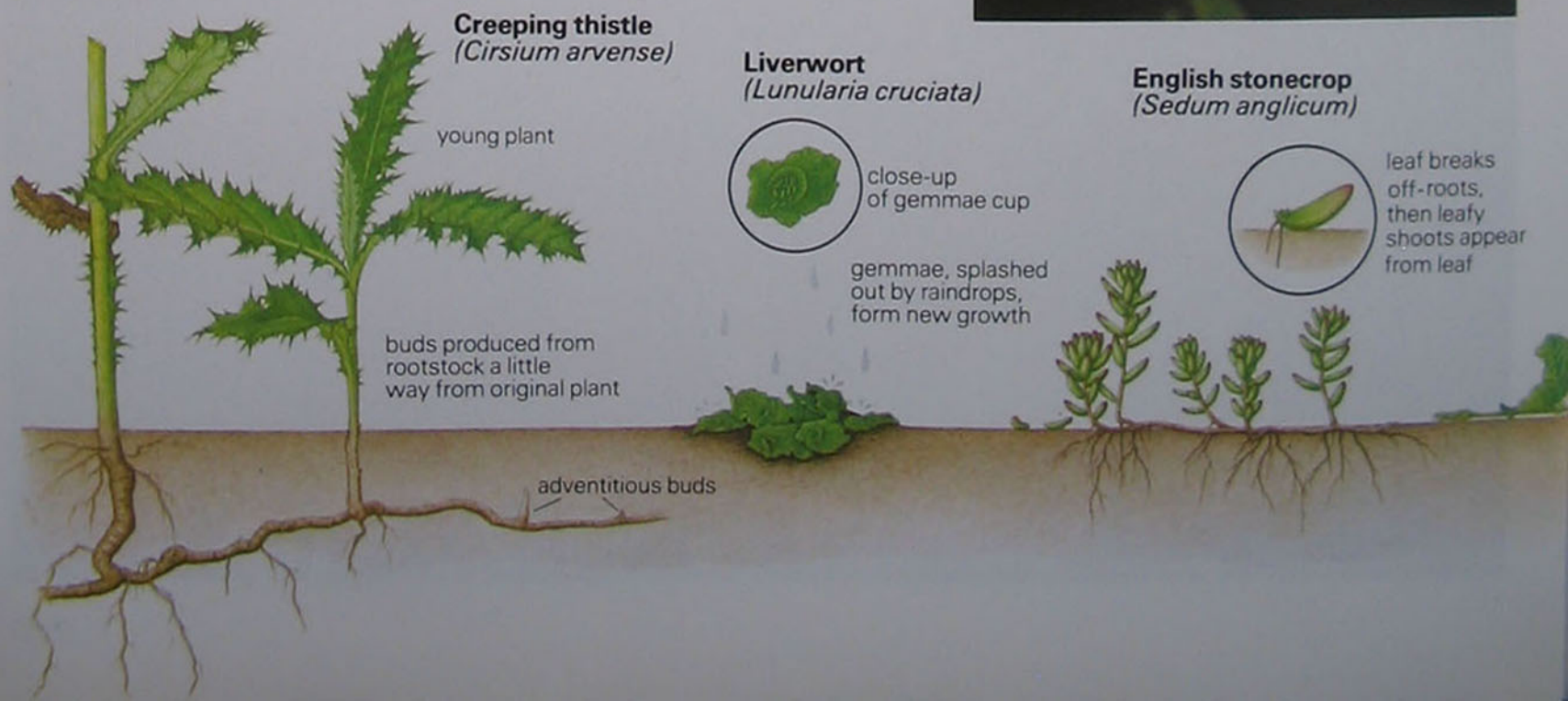
Many species of grasses and sedges can reproduce vegetatively by means of underground, creeping stems called rhizomes, which turn upwards at the end to form a new shoot above the ground. Next time you visit the seaside, you may see the strings of progressively younger plants of the sand sedge, which have been produced in this way, marching across the slope of a sand dune.

Leaves, bulbs and bulbils Occasionally, it is possible for a single leaf to form a new plant. The fleshy and rather brittle leaves of the English stonecrop are easily broken off from the parent plant. Since they have their own built-in water store, they do not die immediately but may be able to seal off the damaged leaf base. Then tiny roots grow, followed by leafy shoots that form a new plant.

Bulbs, such as those of the bluebell, are largely composed of the fleshy bases of leaves with a short section of stem at the bottom where the roots develop. The bluebell is able to bud off new bulbs at the base of the main bulb, and these will produce new shoots the following year.

Crow garlic is unusual in producing tiny bulbs known as bulbils among the flowers of the flower head. In some plants, no flowers at all are produced–just dozens of bulbils, each one capable of producing another plant.

Flowerless plant reproduction Such plants as the mosses and liverworts have unusual methods of vegetative reproduction. Clusters of vegetative cells, known as gemmae, are produced on the leaves, stems or flattened thallus of many liverworts. These gemmae



and associated structures appear in variety of shapes and sizes and each capable of forming a new plant. The woodland moss *Aulacomnium androgynum* produces gemmae in masses on the ends of stalks, giving the whole plant the appearance of a pincushion. Many of the liverworts bear special round or half-moon shaped gemmae cups on the surface of the flattened thallus. A single raindrop falling into a cup scatters dozens of gemmae.

Everlasting plants Vegetative reproduction is essentially a continuation of the normal growth of a plant, extending its life indefinitely. There are no special cells involved such as those produced during flowering, and new plants or shoots are produced from parts of the original plant, continuing to grow after the original has died away.

There are a number of advantages to producing new plants in this manner. One is that the part of the plant that enables vegetative reproduction to take place is very often the same organ that stores food to help the plant survive the rigours of winter–bulbs, corms and rhizomes for example. This ever-present food store helps the plant to cope with competition. A seed produced by sexual reproduction and germinating among established plants has to compete with them for the basic necessities–light, water and mineral salts–in order to grow and reach maturity. The surrounding plants have well-developed root systems already, and ample foliage which prevents the sunlight essential for photosynthesis reaching the seedling. As a result, it is hardly surprising that many seedlings never survive.

However, a new shoot from a species such as meadow grass is produced as a tuft of leaves sprouting from the tip of the rhizome. It is stronger and has a much better chance of survival than the seedling since it is still connected to the parent plant and can take full advantage of the original plant's food reserves.

Many of the species that reproduce vegetatively from bulbs, rhizomes or corms have a further advantage. They are able to grow and flower early in the spring, due to the food reserves in these storage organs. This enables them to set seed before there is a great deal of competition from summer-flowering species.

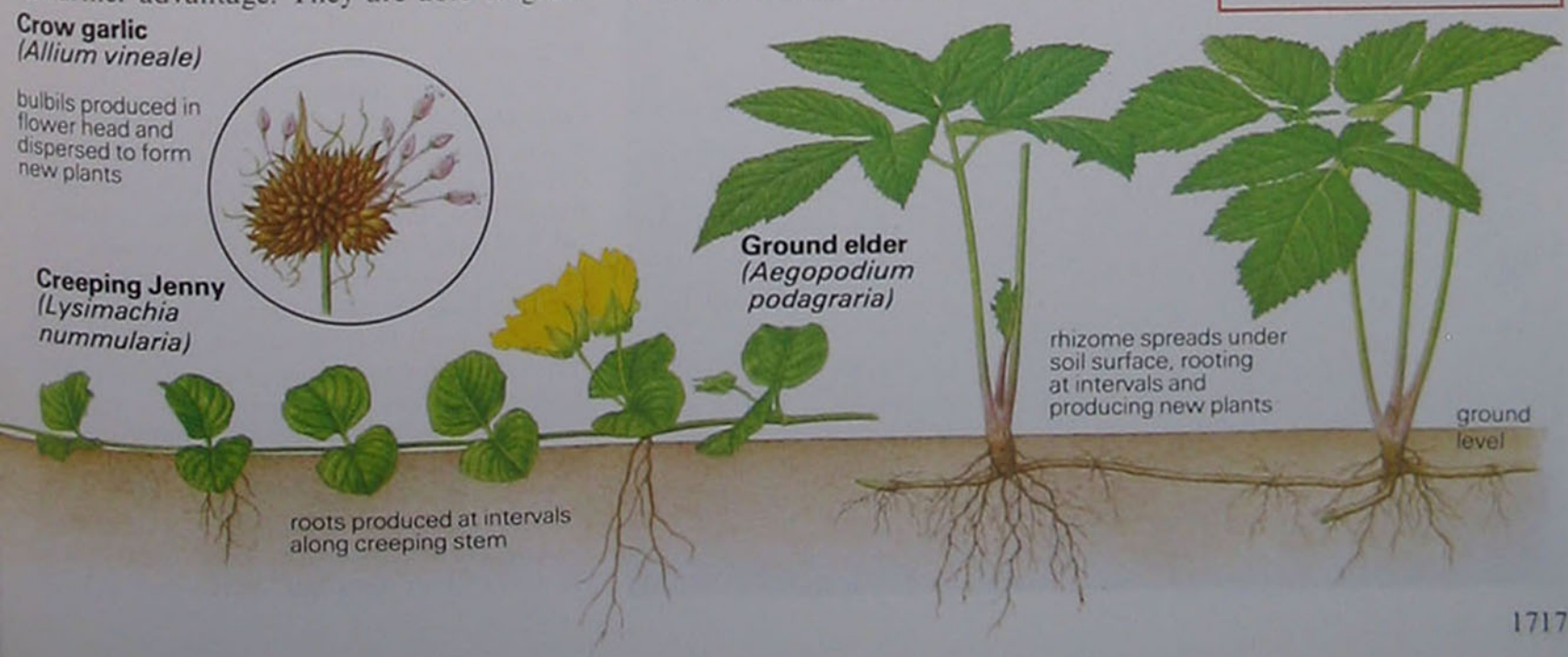
Above: Vegetative reproduction of ground elder causes problems for the gardener as it makes this troublesome weed very difficult to eradicate.

Survival strategies Vegetative reproduction can be a means of survival when the original plant is destroyed by disease, or when it is not possible for a species to flower, or for pollination to occur, in a particular region. In this case, vegetative reproduction allows new plants to appear and ensures the survival of the species in the region.

However, one disadvantage of vegetative reproduction is that there is none of the variation normally associated with reproduction from seed, and the offspring are more or less identical to the parent. Consequently, plants that might be better adapted to the environment than the original cannot be produced. This is particularly important if the environment changes: a species that was wholly restricted to vegetative reproduction could not evolve and must eventually die out.

Rooting stems

The brittle stems of Canadian pondweed are broken easily by passing boats, waterfowl or the water currents. However, each broken length produces roots, forming a new plant.

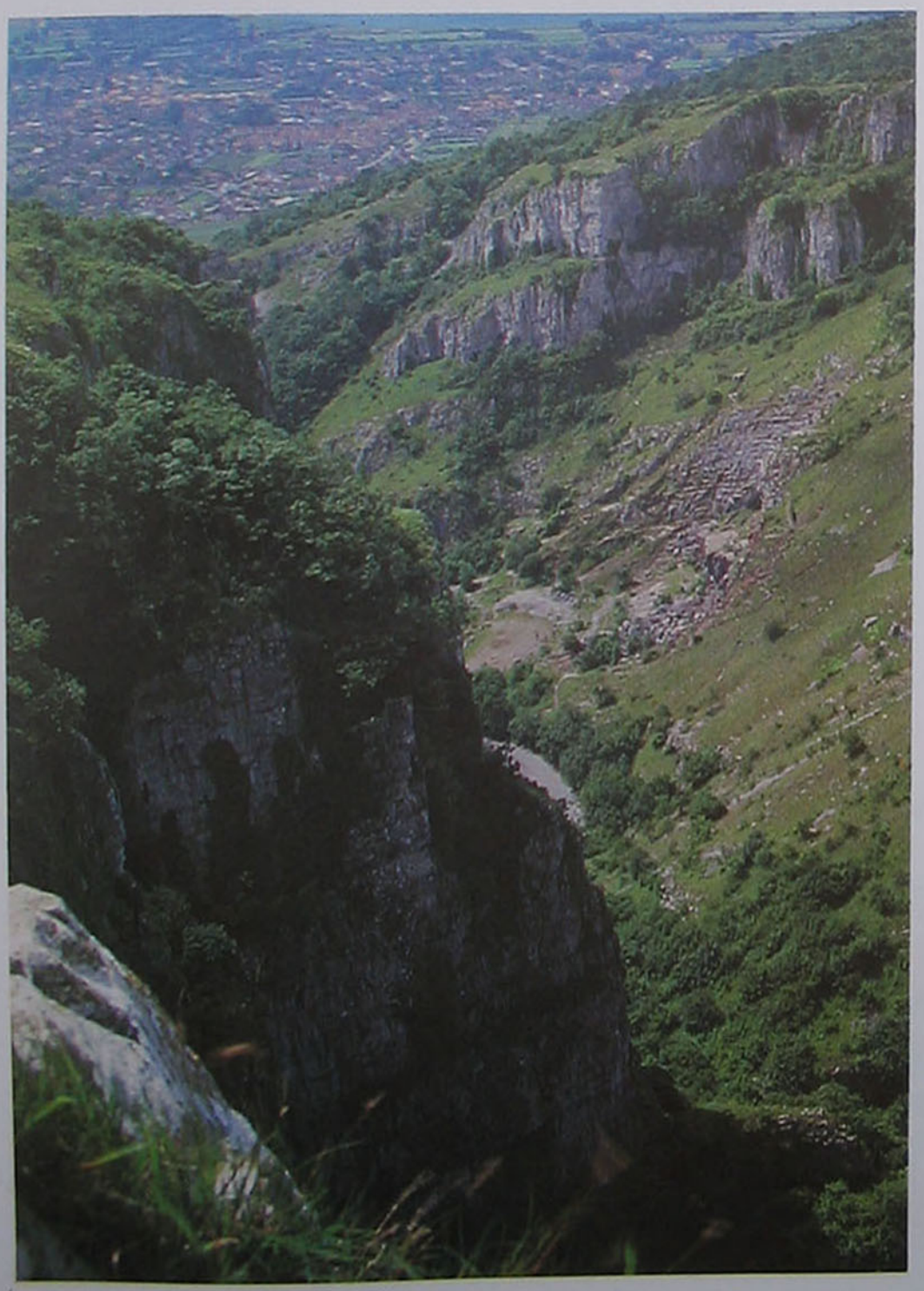


ROCK GARDEN ON A GRAND SCALE

Apart from its national fame as a beauty spot, Cheddar Gorge in the Mendips is renowned for its wealth of unusual and rare plants, but there are many insects and birds to be seen there as well, dwelling in a wide range of different habitats.

Below: Cheddar Gorge from the south side. Cheddar is special in having habitats never touched by man—the cliffs and cliff ledges in particular—in which such species as the rare Cheddar pink can flourish.

The Mendip Hills rise like a wall to the north of the Somerset Levels and, though they barely reach 300m (1000ft), they contain some of the most impressive rock scenery in Britain. The hills themselves are formed mainly from Carboniferous limestone—a much harder, older limestone than chalk—and in places have been eroded to form deep gorges or coombes, the most famous of which are the Avon Gorge, Ebbor Gorge, Burrington Coombe and, best-known of all, Cheddar Gorge. Among the dramatic cliffs and slopes of these gorges are the series of famous Cheddar Caves.



The Gorge The gorge itself is about 2.5km (1½ miles) long and runs almost east-west through the valley, continuing up into the hills and gradually becoming shallower and less dramatic. The road follows the gorge through its most spectacular part, but turns away at Black Rock, leaving the upper part of the main valley quiet and peaceful.

The cliffs in the lower part tower almost sheer to a height of about 120m (400ft) above the valley floor, and are particularly impressive from the south side. Where they are not sheer from the top to the road, the cliffs on the south side drop in a series of spurs and ledges. The north or north-west slopes are gentler, though broken by frequent smaller cliffs and rock slopes. Both north and south sides provide a wide range of habitats, many of them quite inaccessible, and the result is a natural rock garden on a grand scale.

Cliff-top plants The inaccessible ledges are rich with a mixture of limestone grassland, cliff and woodland plant species. They are now the main (if not only) home of the lovely Cheddar pink, which still grows in fair numbers but which was once much more widespread. Since 1975 it has been one of the elite group of totally protected species—it is now illegal to pick any part of the plant (including the seeds), or to uproot it, without a licence. Some of the other plants of this habitat are almost as rare. Particularly notable species include several of our very rare native whitebeam/wild service tree hybrids (some of which occur only in the British Isles), though the common whitebeam is found here, too.

One of the most interesting species of these cliff areas is the cut-leaved self-heal, discovered for the first time in the wild in Britain at Cheddar in 1906. This species is still very rare, found in only a few localities in Britain, yet it is still not really certain whether it is a native plant or not. The particular feature giving rise to this uncertainty is the odd fact that, though the plant often occurs as the pure species, it gradually hybridises with the widespread common self-heal, until only the hybrid occurs, with none of the original rarer species remaining. The presence of the original species suggests that it has not been in Britain very long, and that new populations are arising from garden escapes, or from other sources.

A species widespread and common on the cliffs (and elsewhere in the gorge), though absent from the rest of Somerset, is the lesser meadow-rue, an inconspicuous plant though one that is attractive on closer inspection of its maidenhair fern-like leaves and delicate

wind-pollinated flowers. There are many other species of interest in these upper cliffs as well, including the beautiful bloody crane's-bill, orpine, rock-rose, Welsh poppy and nettle-leaved bellflower.

The north slopes are much less dramatic than the south, being more akin to steep, limestone grassland, albeit with outcrops of rock and scree. Many of the plants are the same as on the south side, though the rare yellow rock stonecrop is particularly abundant here, and many uncommon scrub and grassland species, such as the green-winged and early purple orchids, the pale St John's wort and the mountain sedge, are at their finest here.

Parasitic speciality Another plant that can be found on the cliffs of Cheddar is a peculiar little species called the ivy broomrape. Ivy tumbles down parts of the limestone cliffs in great curtains, and in a few places where its roots are near the surface the rare ivy broomrape grows on it. The broomrapes are a group of parasitic plants that attach themselves to the roots of their host, deriving the whole of their nutritive requirements from them. Consequently they have no need of green leaves and their visible parts consist simply of a brownish or pinkish spike of flowers.

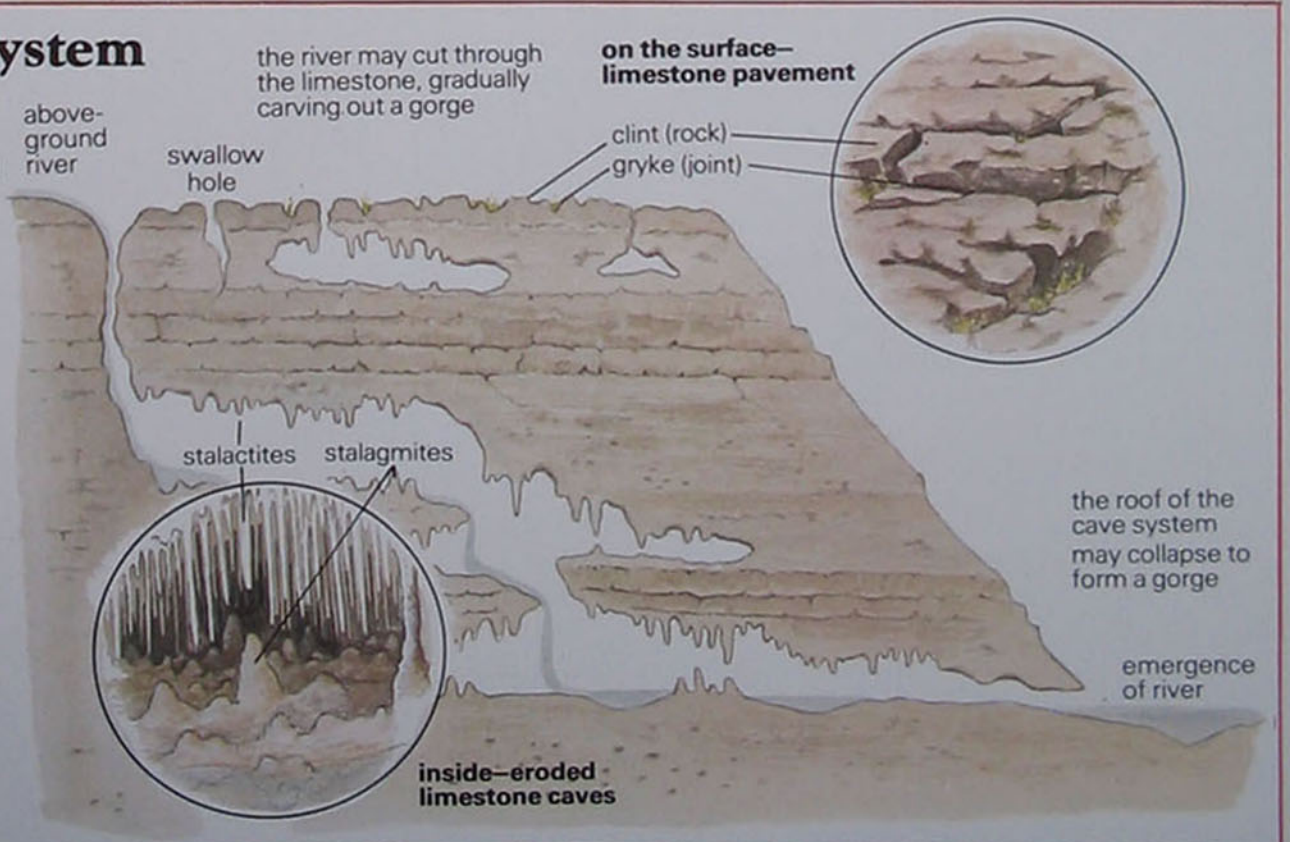
Woodland and caves Higher up, around and above Black Rock, the gorge becomes more wooded, with fine, though rather stunted, ash, oak and wych elm woods with quite a different range of species. A few plants–orpine and spotted orchid for instance–grow both in the woods and on the cliff ledges, but there is also an abundance of the more specialised woodland plants, such as herb paris, hart's tongue and other ferns, and rarities like the narrow-lipped helleborine and

Above: One of Cheddar's many caves, with stalactites and stalagmites. Note the green algal growth flourishing on the walls.

Left: Cheddar's cliffs are frequented by a variety of birds, although the pressure of visitors keeps their numbers down. Jackdaws fly in large flocks over the gorge, ravens breed sporadically there, peregrine falcons have had an eyrie on the cliffs for many years, and sparrowhawks (shown here) can also be spotted.

A gorge/cave system

There are various theories about the origin of Cheddar Gorge. It could be the result of a collapsed cave system, or a chasm caused by earth movements. However, it is now generally thought to have been formed by stream or river erosion, probably in two stages. The initial gorge may have been formed by a river flowing from the Mendip plateau and eroding the limestone, eventually finding its way down a swallow hole and carving through the porous limestone until it developed caves (right) and sank underground to follow a new course. Then, during and soon after the most recent glacial periods, the caves filled with silt and froze solid, the melt water from the snows and ice of the hills being channelled down the gorge every spring and summer and cutting it deeper and deeper.



Above: Lead has been mined at Cheddar since pre-Roman times, the workings reaching a peak in Roman and early Medieval times. The legacy is still clear in the spoil heaps and washing areas, for they colonize very slowly. The remaining high levels of lead and other toxic compounds in the soil have allowed a specialised flora to develop, such rarities as alpine pennycress and spring sandwort (shown here) flourishing in the absence of competition.

Left: The species for which Cheddar is justly famed – the beautiful Cheddar pink.

Below: The limestone-rich grasslands of Cheddar are frequented by a variety of butterflies – including this marbled white.

the parasitic toothwort here and there. Woodland birds include redstarts, wood warblers, all three woodpecker species, nuthatches and many others.

The uppermost valley is a beautiful mosaic of woodlands, scrub and sheltered, species-rich limestone grasslands which, not surprisingly, support abundant butterflies and other insects. Some 30 species of butterflies have been recorded for the valley as a whole, two of the most attractive and conspicuous in the upper valley being the dark green fritillary and the marbled white.

There are many small caves throughout the area, but the best-known ones are the two open to the public – Cox's Cave and Gough's Cave, of which Gough's is the larger.

The caves are of particular interest to the naturalist for two main reasons. The first is their population of bats, including the greater and lesser horseshoes, which find sanctuary in the vast system of constant-temperature caves. The second point of interest to look out for is the way that ferns, mosses and liverworts have colonized the caves as far as a quarter of a mile in from the entrance, depending entirely on illumination from the artificial lights provided to guide visitors.

Too many visitors, too little grazing In spite of the tremendous level of natural history interest throughout the gorge, the area has certain problems, deriving essentially from two main sources – the vast number of visitors and the lack of grazing on the slopes.

Remarkable numbers of people visit Cheddar every year, and though most stay around the main attractions and developments in the lower gorge, many find their way on to the cliffs and slopes. The problems this has caused for rarities like the Cheddar pink are numerous – including casual picking, and the devastating wholesale uprooting and removal to gardens and nurseries. Although the pink has been protected since 1975 and is beginning to recover, it is unfortunate that not everyone observes the law concerning it, nor is necessarily even aware of the prohibition. It also seems certain that another rare species – the mossy saxifrage – has become extinct in Cheddar. Although it was the 1976 summer drought that caused its final demise, there is little doubt that previous collecting reduced its population to a size where it was very vulnerable. Severe visitor pressure also causes erosion of the lower slopes, and damage to some of the ledges.

The slopes of the gorge were once grazed heavily by sheep, rabbits and goats, but now there is virtually no grazing at all. The result is that coarser grasses and scrub are steadily replacing the species-rich grasslands and ledges which have depended on grazing for their existence in the past. There is no immediate danger of all the rarities disappearing, but the changes are considerable and seemingly inexorable.

TREE TRUNK CLIMBERS

The treecreeper can be seen in woodland, spiralling up tree trunks and clinging to the bark with sharp claws. It pauses to seize insects with its fine, down-curved beak.

The birdwatcher's first impression of a treecreeper is of a small, brownish bird, fluffy in appearance and furtive and jerky in its movements. It is often seen feeding in its characteristic manner–it creeps up the trunk of a tree in short stages, searching for insects, and when it cannot usefully hunt any higher it flies across and down, to start again at the base of another trunk.

Adult treecreepers are brown above, with various darker and paler streaks, and off-white below; the sexes are alike in plumage and general appearance. In good lighting conditions and during dry weather, this white can appear almost silvery, shading to fawn on the flanks, but in damp weather, when the belly has been pressed close against the bark of damp tree trunks, it can appear brownish or even greenish, smeared with material such as algae rubbed off the bark. The tail is long and brown, and the wings are short and rounded, with a conspicuous pale crescent-shaped wingbar in flight. Climbing up a tree trunk, treecreepers seem long, slender birds, but seen in flight–which is deeply undulating and looks rather feeble in character–they appear much fatter and almost moth-like, so rounded are the wings.

Young birds are if anything slightly fluffier than their parents, particularly around the white under-tail coverts, and the feathers of

Below: Treecreepers nest in slender cavities in tree trunks, or behind a flap of peeling bark on a dead or dying tree. The cavity usually has two entrances–or rather, one of them acts as the emergency exit!

the head and back each have a yellow-buff fringe, giving the upper parts a scaly appearance. This lasts only from when the chicks fledge in the summer until September, when the moult of body feathers is completed.

Head, tail and toes Treecreepers feed mostly on small insects, spiders, other bark-living invertebrate animals, and their eggs and larvae. Their long, slender, finely pointed beaks are down-curved, and are ideal for extracting such tiny items from the crevices in the bark in which they are hidden. The eyes are large, and protected by unusually prominent eyebrows for a small, slow-flying bird. The advantage of these 'beetling' eyebrows is not known, but a close-up view through binoculars reveals that they give to the otherwise docile-looking treecreeper an extremely bad-tempered expression, additionally emphasised by the long, bold white eyestripe.

The long tail closely resembles that of the woodpeckers, with the shafts of the central feathers specially strengthened. As in the case of the woodpeckers (to which, however, treecreepers are not related), the tail is used as a prop, the treecreeper normally moving head-uppermost on trunks and branches.

Compared with the powerful claws, toes and legs of the woodpeckers, treecreepers seem poorly adapted to their arboreal habitat. Unlike the woodpeckers' toe arrangement (two facing forward, two behind for maximum grip), the treecreepers have the same pattern as almost all other passerine birds–three in front, one behind. The toes and legs seem slender and feeble, but the long and sharp claws can cling easily to the bark.

Above: Once they have left the nest, the brood of young follow their parents from tree to tree, clambering up the bark in a comical train. If they are disturbed they tend to 'freeze', beaks pointing skywards, hoping to escape detection with their excellent camouflage.

Tree-dwelling birds

1 The coal tit is typically found in the upper crown, feeding on tiny insects under leaves. **2** The willow warbler also feeds on insects that it finds among the foliage in the outer crown. **3** The nuthatch eats nuts and seeds–fresh or windfalls–as well as insects and small creatures in dead wood. **4** The treecreeper searches upwards from the base of the trunk for insects and other small creatures. **5** The great tit is typically a ground or lower branch feeder, eating a mixture of invertebrates and seeds. **6** The great spotted woodpecker often nests in holes in the dead wood and eats insects and larvae beneath the wood surface. **7** The hawfinch is a seed eater and often feeds in the outer crown, where it takes the ripe seeds direct from the tree. It is particularly attracted to hornbeam seeds–the tree shown here is a hornbeam. Those birds that feed mainly on insects (**1**, **2** and **4**) have long, fine beaks, while those mainly eating seeds (**7**) have large beaks.

Song and display The birds are most vocal, and most easily seen, in late winter and in early spring, when there are few leaves on the trees. The song, high-pitched and silvery in tone, is a descending trill with a small last flourish of three clear notes, recalling the songs of willow warblers and chaffinches. It is at this time of year that treecreeper pairs display: a novel performance as the birds chase each other in spirals up tree trunks.

Single brood The first eggs are laid early in April, but the peak laying period is in late April and early May. It seems that the majority of pairs are single-brooded, and that the eggs found freshly laid in early June are replacements for clutches lost to predators.

A hollow in the bark An intriguing feature of the treecreeper is its use of winter roosting sites in enormous Wellingtonia trees. The bark of these North American introduced trees–relatives of the redwood–is thick and papery, and easy even for the slender beak of a treecreeper to excavate. Close inspection of almost any Wellingtonia anywhere will show some of these roosting sites a few feet from the ground. They are cavities, roughly the size and shape of a hard-boiled egg cut lengthways, and usually there is a give-away trickle of white droppings running down from them. The treecreeper snuggles down into this hollow, fluffy feathers bristling for the best insulation, and becomes almost invisible, so good is its camouflage.

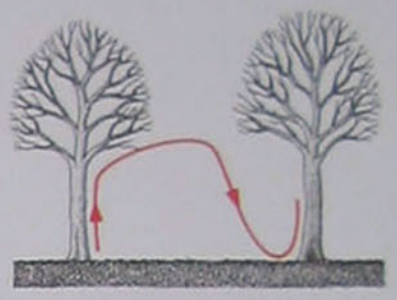
Change of habitat In Britain and Ireland, treecreepers seem to be most numerous in deciduous woodland and quite scarce among conifers. On the Continent of Europe, there are two treecreeper species: the one that is common in Britain and Ireland, and the short-toed treecreeper. There are very small differences in some anatomical measurements, and equally small differences in plumage, but these are not reliable for identification. Their songs, though, are quite different, and so too are their habitats. Astonishingly, it is the short-toed treecreeper that is found in deciduous woodland on the Continent, while 'our' treecreeper is almost confined to upland conifers.

The explanation for this is thought to be that after the last Ice Age (which ended about 10,000 years ago) the two species recolonized Europe at different rates. 'Our' treecreeper spread northwards with the coniferous forest, which was its natural habitat, and which grew in Britain and Ireland some centuries before the deciduous woodland.

The English Channel and the North Sea formed during the period of recolonization, isolating Britain and Ireland before the deciduous woodland–and the short-toed treecreeper–arrived. When, subsequently, the conifers were mostly replaced by deciduous species, the treecreeper was able to adapt itself to the changed habitat in the absence of competition, as the Channel proved an effective barrier to the short-toed treecreeper.

Treecreeper (*Certhia familiaris*): resident in woodland and parkland. Length 12.5cm (5in).

Below: The typical feeding route–working up each tree in turn.



Opposite: In their well-protected nests, treecreepers suffer relatively few losses of their young to predators. The fewer losses may explain why single-brooded treecreepers can maintain their population with a clutch size of five when the tits, also usually single-brooded and also hole-nesters, need average clutches at least twice as large.

Below: Bringing food to the nest–the recipients are completely hidden from sight.

THE HOUSE MOUSE: AN URBAN SQUATTER

Britain's most successful mammal, and probably the most familiar, is the ubiquitous house mouse. It thrives in man-made environments and, in ideal conditions, may produce up to fourteen litters of a dozen or more young each year. Five to ten litters of five or six young are, however, more usual.

HOUSE MOUSE (*Mus musculus*)
Size of adult Max weight 30g (1oz). Max length head and body 9cm (3½in), tail as long again.
Colour Dark brownish-grey above, greyish-buff below. Tail thick, almost naked, with conspicuous scaly rings.
Breeding season From March to October in countryside. In urban areas breeding may be continuous.
Gestation 19-20 days.
No of young 4-13 or more, but 5-6 is average. About 5 litters in urban areas and 10 in corn ricks is average.
Lifespan Few live longer than 18 months, most die in first winter.
Food Omnivorous, preferring grain, grain products; insects, man's food.
Predators Birds of prey (barn owls), mammals (stoat, weasel, man, rats, cats).
Distribution Throughout UK.

The most successful mammal in Britain, and probably the most familiar, is the house mouse. It is not a native: like the rabbit, grey squirrel, and many other species, it was introduced by man and, like house mice worldwide, it has shared his home ever since.

Excavations of fossil remains in Dorset show house mice to have been present in Britain at least since the pre-Roman Iron Age. The British subspecies is one of the most commensal races of house mice. (Commensal animals are those living in close association with another species–in this case, man.) Its ancestor, another subspecies, still lives wild in the Steppes of Central Asia. Since prehistoric times it has colonized vast areas of the world and today it is well adapted to a cosmopolitan existence: it can live for long periods on dry seeds and little or no water; it has a high reproductive rate, and is small, agile and alert; and above all it thrives in a man-made environment.

It is helped in this respect by man himself. On the whole we are wasteful creatures with untidy feeding habits, and we usually leave plenty of food lying around for the mouse to find. Our homes offer hiding and nesting places, and a warm environment for breeding.

Many variations Throughout its worldwide range the house mouse is extremely variable in appearance. In all, some 130 forms have been described, but only about 20 are thought to be true subspecies.

As with most of the commensal forms, the British house mouse is larger and darker than its ancestor, with a longer tail. The coat is greyish-brown above and slightly lighter greyish-buff below. Its eyes and ears are smaller than those of the wood-mouse, it has a thick, almost hairless, scaly tail, and a notch in the upper incisor teeth which is visible in side view.

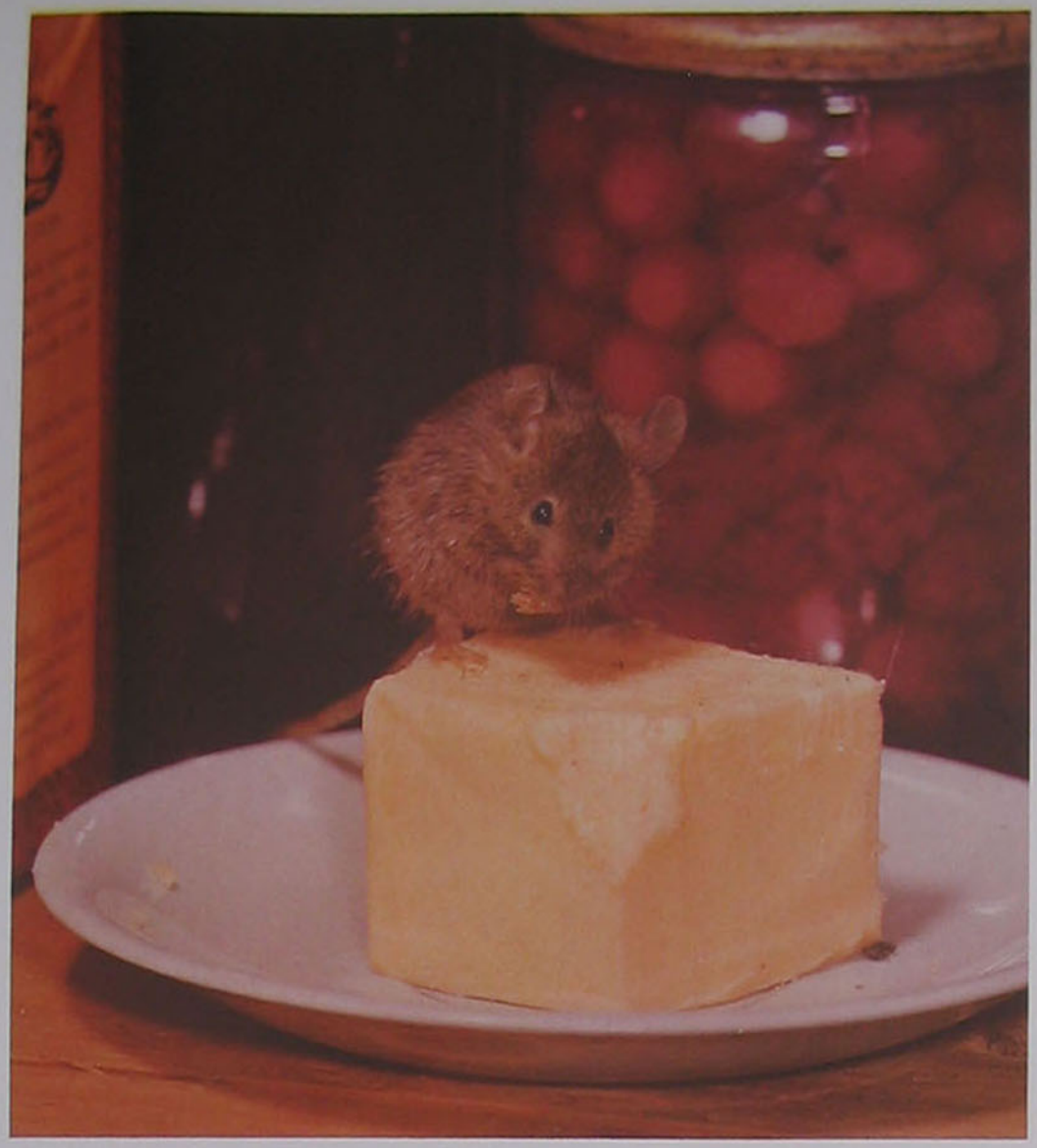
Another subspecies of the house mouse, and one which has helped to pay for the activities of its destructive relatives, is the tame laboratory animal. First imported to Europe from Japan, the laboratory mouse has for many years been of great value to man in the studies of medicine and heredity.

Town mouse, country mouse House mice are social animals, living together in small groups dominated by a single male. Not all house mice live urban lives. There is also a thriving rural community. Others, the feral house mice, are found in fields and hedgerows in arable districts.

Urban mice make their homes in the many holes and cracks abounding in town build-

Left: Fourteen-day old house mice and (below) young mice and their mother in their nest. Town mice make nests of sacking, paper, fabric, clothes or string but in the countryside grass, leaves and straw are used.

Opposite: The house mouse common in north-western and western Europe is descended from a subspecies found in Central Asia. It has been associated with man since prehistoric times and its range has expanded as trading has increased.



Above: The urban house mouse is truly omnivorous, eating almost everything that man feeds on, and even on such strange items as plaster, glue, soap, candles and wood. If given a choice, house mice prefer grain and grain products, such as bread. They can remember tastes for a period of time, and avoid food that has disagreed with them—one that has been poisoned and made them ill, for example. They do not store their food.

ings. Of all the house mice, those living in dwelling houses probably work hardest for a living. They are more disturbed by the movements of man and domestic animals and have to search more diligently for food than mice in warehouses or farms. The home range of individual mice is determined by the availability of food and cover. Urban house mice, which often have their hiding places and food source close together, usually have home ranges of five square metres.

The rural population is less localised and can be greatly influenced by farming practice. In summer, rural house mice that have been indoors during winter often leave for fields and woods, feeding on field crops, seeds and berries. In autumn they return indoors for food and shelter. Rural house mice are less markedly commensal than their urban relatives, and if evicted from corn ricks and farm buildings often migrate to fields and hedgerows.

The feral mice are more like their wild ancestors. They live independently of man, in subterranean burrows.

Island habitats House mice are also present on most British inhabited small islands. If the island becomes uninhabited, the mice revert to a feral existence. Isolated communities of house mice are particularly interesting to scientists because they show the rate at which new genetic characteristics can develop. The subspecies of house mouse in the Faeroes, for example, whose forerunners are known to have been introduced between 250 and 1000 years ago, have diverged from mainland mice both in coloration—they are smoky grey with a cream underside—and in increased size.

In and out of doors Territorial aggression between males can become intense, especially in over-crowded conditions, and strange mice of either sex entering a territory are attacked. There seems to be more tolerance in mice found in buildings than in habitats such as corn ricks, where exceptionally dense populations can build up.

House mice are largely nocturnal, although they adapt to the activities of the human occupants of dwelling houses. They only stray into new areas when food is in short supply. They prefer grain and grain products such as bread. Rural house mice eat mainly grain and seeds, especially wheat, but their basic diet is supplemented with insects. Occasionally worms, arthropods and fungi are eaten. The average daily intake is 3g ($\frac{1}{16}$oz).

House mice can survive on little water, although animals feeding on dry seeds for long periods can have lower than normal fertility. In corn ricks mice obtain the balance of their water from dew or rain on the outside of the rick.

Fast breeders House mice owe much of their success to their high rate of reproduction. Females can breed at 40 days old and normally produce between five and ten litters annually, depending on where they live. Country mice tend to produce more litters. There is no breeding season as such, but feral mice living under 'natural' conditions bear their young between March and October. In favourable conditions in urban habitats and corn ricks breeding is continuous and up to 14 litters have been known.

Single or communal nests are made. In the crowded conditions of a corn rick, it is common to find nests of several young families. The average litter is five or six, and the young are weaned during their third week, by which time they are beginning to leave the nest for short explorations, and the female is pregnant with a new litter.

As the population density increases, so does

Mice in cold storage

One of the most unusual places in which house mice have been found is the cold store where meat is kept for long periods. In these extreme conditions, where the temperature falls to −10°C (14°F), the house mouse thrives in almost total darkness, feeding on frozen meat and burrowing into the carcasses to make nests of the hessian material in which the meat is wrapped. The mice have adapted to these conditions by becoming larger and heavier than mice living in more normal circumstances, and by increasing their reproductive rate to an average of a little over 6.5 litters a year.

Scientists who have reproduced these conditions in laboratories discovered that of the 14 generations of mice they bred, only the first and second generations showed distinct abnormalities—heavier hearts and stomachs, shorter tails, longer fur—as a result of the cold. Later generations showed virtually no physical differences from the control mice reared in warmer conditions.

the fighting. Males tend to live with one or more females in territories that are vigorously defended, but at high population densities fighting can be intense and subordinate animals eventually lose their territories and breeding rights. If the population becomes too great, a natural 'birth control' becomes effective: reproduction is checked as many of the females become infertile and cease to bear any young.

During the year a female produces 30 to 50 young. Some fall prey to natural enemies, most die during their first winter, and few live longer than 18 months. The reputation of the domestic cat as a mice controller is much overrated. In some places, such as warehouses, cats used for mice control can be as unhygienic as the mice themselves.

House mice are agile and can scuttle away fast. Their senses of hearing and smell are acute, and they can see sudden movement near to them. By far their greatest predator is man, who has been trying to control them from the very beginning of the association. Excavations in Afghanistan have unearthed pottery mouse-traps about 6000 years old.

Mice damage The damage caused by mice is not as great as that done by rats. Reliable statistics for Britain are not available, but in grain stores where mice are present up to 16% damage has been suggested. Mice not only eat, but contaminate and damage grain, removing the outer husk to eat the white endosperm contained inside.

Above: House mice advertise their presence by their distinctive black droppings.

Mice are also carriers of disease and parasites. They no longer carry plague fleas, but they are still a risk to human and animal health. They carry disease and infections such as food poisoning, caused by Salmonella bacteria, and leptospirosis, a bacterial infection that attacks the liver and kidneys. The anticoagulant poison, Warfarin, which prevents blood clotting, has been used against them since the 1950s, but during the late 1960s population increases were reported. Since then house mice have shown increasing resistance to this kind of poison, and other controls have been used with some degree of success.

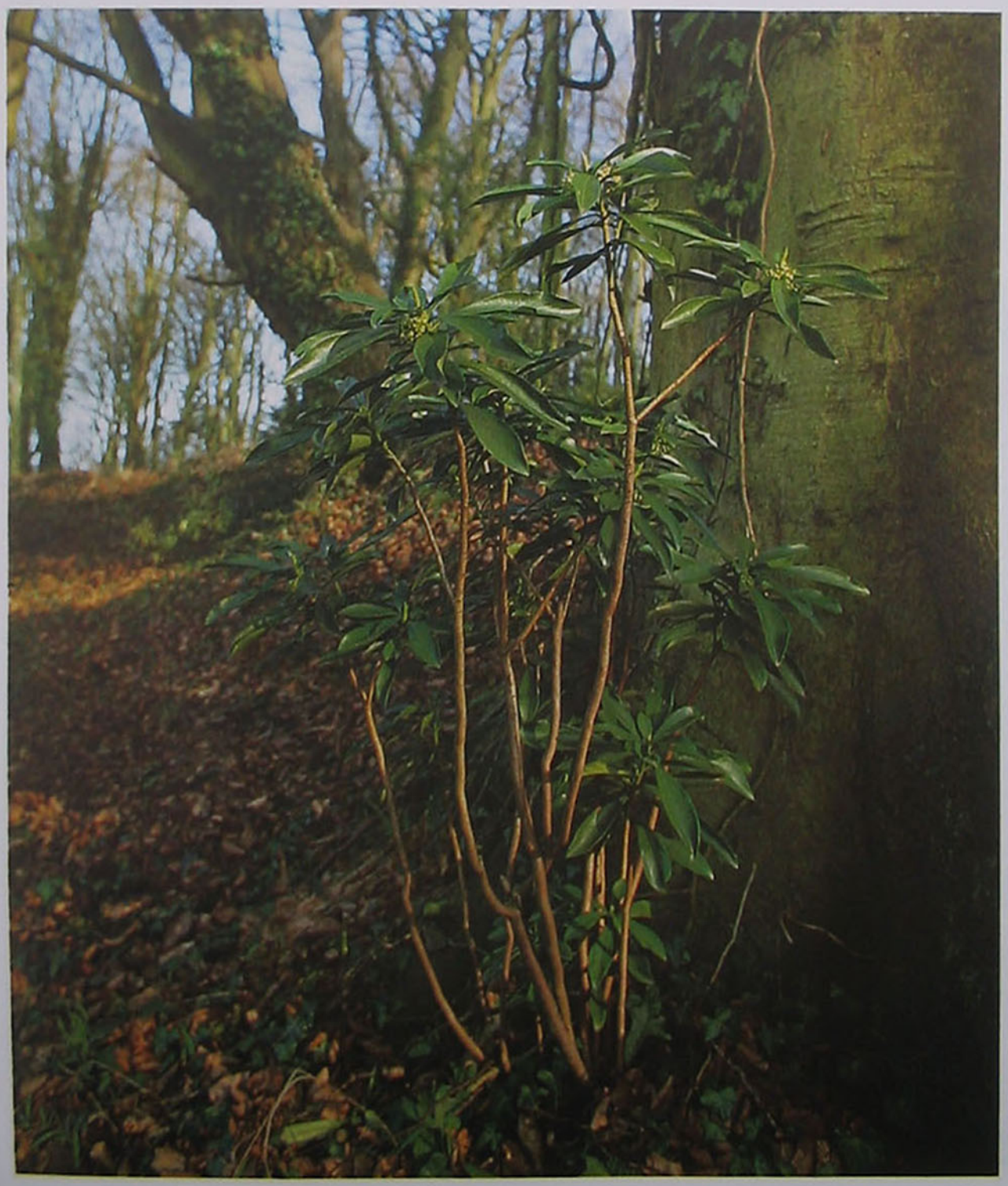
Below: In the past, when harvested corn was stored in sheaves, rural house mice built up considerable populations in the corn ricks, finding food, shelter, nesting material, protection and an even temperature. 2000 mice at a time were commonly evicted from a single rick during threshing. Today the mice try to enter the granaries where the grain is stored.

INCONSPICUOUS SPURGE LAUREL

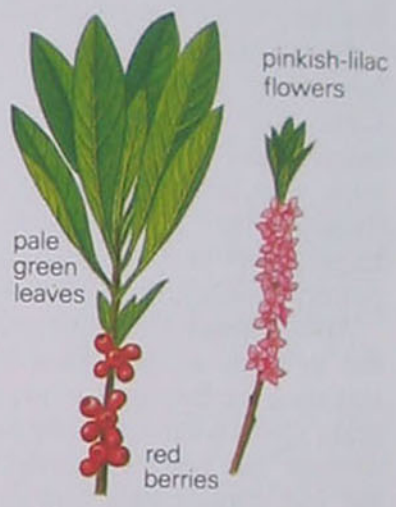
Britain's broad-leaved woods abound with small inconspicuous shrubs growing beneath the tree canopy. One such is spurge laurel, a shrub most easily spotted during the winter and early spring when it retains its thick leathery leaves while the trees above remain bare.

Although there are two species of the genus *Daphne* native to Britain, this group of small shrubs is more familiar to gardeners than to most naturalists in this country. Neither of our native species can be said to be common and, when not in flower, both are inconspicuous, merging with other shrubs in their favourite habitat on the fringes of woods.

The gardener, on the other hand, sees *Daphne* in a different light. Some of the 70 or so species are beautiful dwarf shrubs and make popular garden plants, particularly as most have delightfully scented flowers. One such is our own native mezereon (*Daphne mezereum*), which bears masses of stalkless pinkish-lilac flowers that cover its otherwise



Spurge laurel
(Daphne laureola)



Mezereon
(Daphne mezereum)

Above: Britain's two native species of *Daphne* are spurge laurel and the much rarer mezereon. Both have the same shape of flower, and bear berries, but the colour and arrangement of the flowers and berries on the two species are quite different, and spurge laurel is evergreen, whereas mezereon is deciduous.

Spurge laurel (*Daphne laureola*). Native evergreen shrub found most often on the fringes of woods, particularly of long-established woodland, or in scrub left over from old woodland. Height to about 1.3m (4ft).

Left: Spurge laurel flowers early in the year, usually in February or March which, as this picture of a spurge laurel flowering in a beech wood shows, is before most of the trees around it come into leaf. Mezereon is another early-flowering daphne, its blossom emerging before the leaves to cover its otherwise bare stems.

bare branches in early spring. In the wild, however, this shrub is now extremely rare and there are only a very few sites in Britain where it can be found.

Britain's other native species is spurge laurel (*Daphne laureola*). This is, perhaps, a less attractive shrub than mezereon but it is much more common, though its distribution is rather patchy. Like mezereon, it requires an alkaline soil, but there is no guarantee of finding it in a wood, simply because it is on limestone or chalk. The best place to find spurge laurel is in long-established woodland or scrub left over from old woodland.

As well as being native to Britain, spurge laurel can be found throughout much of Europe and south to North Africa and the Azores, growing to an altitude of 2000m (6500ft).

Leathery leaves Spurge laurel is an evergreen shrub, no more than 1.3m (4ft) tall, with thick upright stems that are bare except for a cluster of leathery leaves at the tips. The leaves are a dark glossy green and lance-shaped, reaching up to 12cm (5in) in length. Both surfaces of the leaves are completely hairless (as are the stems) and the margins have no teeth.

As with mezereon, the flowers of spurge laurel appear early in the year, usually in February or March. On all species of *Daphne* the flowers are tubular, branching out at the mouth into four lobes. There are four sepals but no petals. Inside, the male stamens are sited near the mouth, while the female ovary is situated at the base. Most flowers in this genus are brightly coloured but those of the spurge laurel are a rather inconspicuous yellowish-green.

The fruits are berry-like (technically, drupes) with a hard stone inside. Like the flowers, they are borne in clusters, and ripen to become glossy black.

Mezereon differs from spurge laurel in several important ways. Its leaves have the same shape but are much paler green, softer and deciduous. The flowers are tubular and a bright pinkish-lilac; they have a delightful smell, unlike those of spurge laurel, which have no smell, except occasionally towards the evening. The berries are red.

Misnomer Spurge laurel is oddly named, for it belongs neither to the spurge family nor to the laurel family. The name 'laurel' was given to it because of its leaves. The same word has for centuries been applied to several other plants, such as cherry laurel and Portugal laurel, none of which is related to the true laurel or bay tree. Provided the plant had shiny leathery leaves and a shrubby habit, it was liable to be called a laurel.

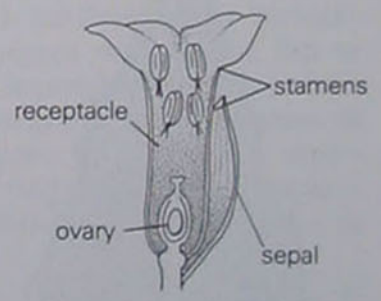
Why spurge laurel was also called 'spurge' is, however, obscure. The word is, of course, well known as a general term for members of the genus *Euphorbia*. Is it a coincidence that a frequent woodland associate of spurge laurel is wood spurge, a plant with a similar shrubby habit? It may be that the ecological association led people to think that the two plants were related and so they gave them both the same name. However, we do not know for sure, and there is no direct evidence to support this.

Both parts of spurge laurel's Latin name relate to the laurel. The connection with its specific name *laureola* is obvious, but with its generic name of *Daphne*, less so. In fact, daphne was the ancient Greek name for laurel. It was so-called because, in Greek mythology, the nymph Daphne turned herself into a laurel tree to escape from the god Apollo.

Purgative properties Daphnes have long been known and used for their purgative properties. (This may, indeed, explain why spurge laurel was given the name 'spurge', which derives from purgative.) Gerard, in his famous *Herbal* of 1590, states that 'it provoketh vomit' and, of the leaf 'being chewed, it draweth water out of the head'.

It is as well to remember that all daphnes contain strongly purgative chemicals and the spurge laurel is particularly dangerous in this respect because its berries are a harmless-looking black, whereas the mezereon's red fruits warn of their danger. Fortunately, however, both the berries and the leaves have a bitter, burning taste that discourages anyone from casually sampling them. Yet, they are avidly eaten by birds.

Above: Spurge laurel can tolerate deep woodland shade, helped by its arrangement of leaves. These usually occur only at the tops of the stems and are splayed out to reduce overlapping. This allows them to catch as much sunlight as possible.

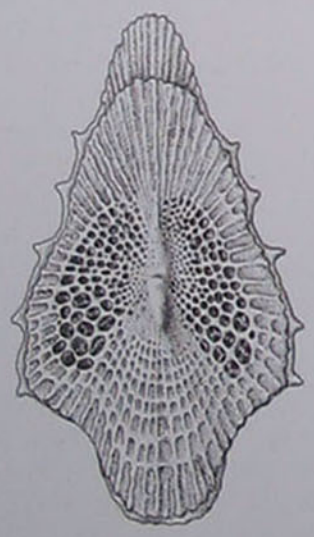


Above: A flower of spurge laurel in cross-section. Each flower consists of a long tubular receptacle that opens out at the mouth into four lobes. Surrounding the receptacle are four sepals—there are no petals. Inside, near the mouth are the stamens and, at the base of the tube, the ovary. Each flower is about 8mm long.

RARE GIANT STURGEON

The largest and one of the rarest of British freshwater fishes, the sturgeon has great commercial value, yet much about this fish remains unknown.

Above: A young European sturgeon. A three-year-old fish is up to 50cm (20in) long but growth rates beyond that have not been well studied for western European stocks. However, researches in the 1930s suggest that a six-year-old specimen is 1m (40in) long.



Above: A sturgeon's head and body possess hard heavy plates called scutes, one of which is shown here. Each scute has a pitted surface and is roughly oblong, with a raised ridge running along the middle.

There are fewer than 25 species of sturgeons in the world. All are confined to the temperate latitudes of the northern hemisphere and, in terms of both numbers of species and numbers of individuals, are most abundant in eastern Europe and the USSR. Only one species of sturgeon is found in western Europe, including Britain, and this is the European sturgeon, often known simply as the sturgeon.

Plated body The sturgeon is a long-bodied fish with a rather pointed snout. Its head is covered with hard, bony plates and there are five rows of similar plates, called scutes, running along the sides of its body.

In many respects the sturgeon seems to be halfway between the primitive sharks and the more highly evolved bony fishes. As with sharks, the sturgeon's backbone continues into the upper lobe of its tail, making this lobe longer than the lower lobe, a feature not shared by bony fishes. Internally, the sturgeon has a spiral valve in its gut – a corkscrew-like arrangement that increases the absorptive surface of the intestine without greatly increasing its length. Again, this is a feature of sharks. Otherwise, the sturgeon resembles bony fishes.

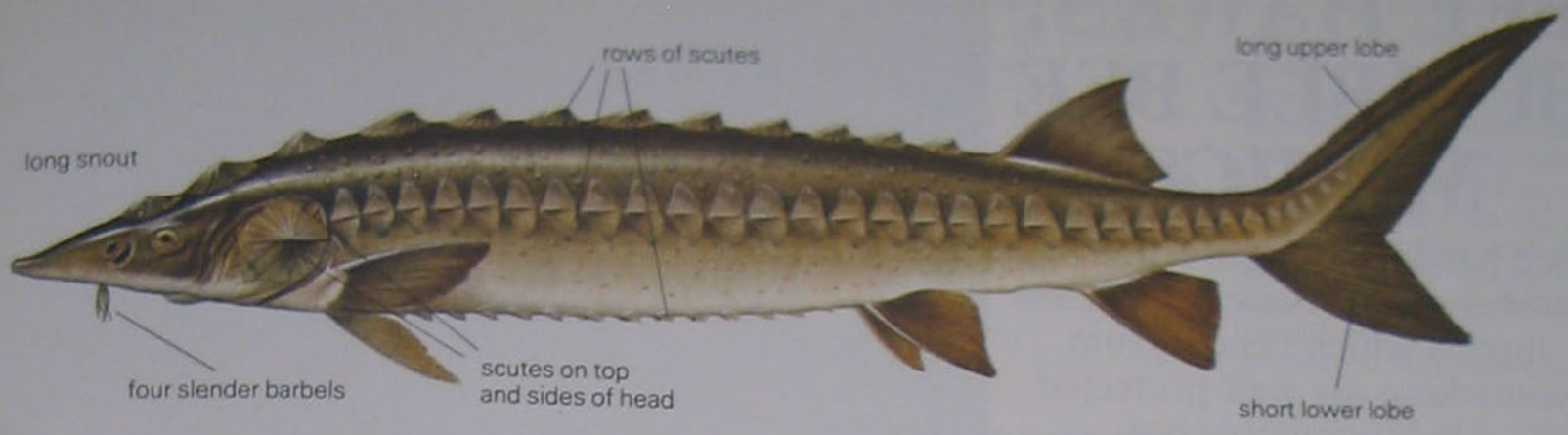
The British species of sturgeon can grow to a huge size – indeed, it is the largest fish to have been found in British fresh water. The largest British report is of a sturgeon caught 24km (15 miles) upstream from the mouth of the River Towy, near Carmarthen in July 1933. It weighed 176kg (388lb) and was 2.8m (9ft 2in) long; it was hooked by a salmon fisherman who, after it had stranded in the shallows, needed a horse and cart to pull it out of the river. An even longer, though lighter, specimen, reportedly 3.6m (12ft) in length, was landed at Scarborough in November 1922.

Population centres The sturgeon lives in both the sea and fresh water. Its present range extends from the Baltic Sea, south to the Mediterranean and the Black Sea, but it is not evenly distributed throughout this area. Instead, it is present in small populations centred on its breeding rivers – in western Europe these are the Gironde in France, the Guadalquivir in the Iberian Peninsula and the Italian Po.

The sturgeon does not breed in British waters and it is extremely rare here. Those specimens that are found are almost always caught at sea, usually accidentally by trawlers. Yet, examining records of the capture of sturgeon in Britain over the last 150 years shows that it used to be caught in rivers fairly regularly in the spring and early summer. As this is the time of year when breeding adults spawn in fresh water, it may well be that the sturgeon once bred here and that the specimens caught were seeking suitable spawning grounds.

Rivers flowing into the Humber Estuary used to feature frequently in these reports:

European sturgeon
(Acipenser sturio)



sturgeons were seen on the Ouse as far inland as Boroughbridge, in the Wharfe to Boston Spa and in the Trent at Nottingham. However, the building of navigation weirs and locks is believed to have ended the sturgeon's migration in British rivers for, while other migratory fishes such as salmon and eels can overcome such obstacles, so huge a fish as the sturgeon is quite incapable of doing so.

Breeding and growth The sturgeon is a migratory fish, spending much of its life in the sea but returning to rivers in the spring to spawn in early summer. Spawning takes place in areas where the current is moderately slow, the river-bed pebbly and the water deep, sometimes as deep as 6m (20ft).

Numerous eggs are laid, as many as 2½ million by a large female. They stick to stones on the river-bed and hatch after three to six days, the young larvae being at first about 9mm (⅜in) long. The young fish stays in the river for between one and three years before heading for the sea.

At the end of three years, a young sturgeon can be as long as 50cm (20in). A male fish becomes sexually mature at about seven years old and the females between eight and fourteen years. Extrapolating these figures shows that the giant fish from the River Towy was probably between 45 and 55 years old.

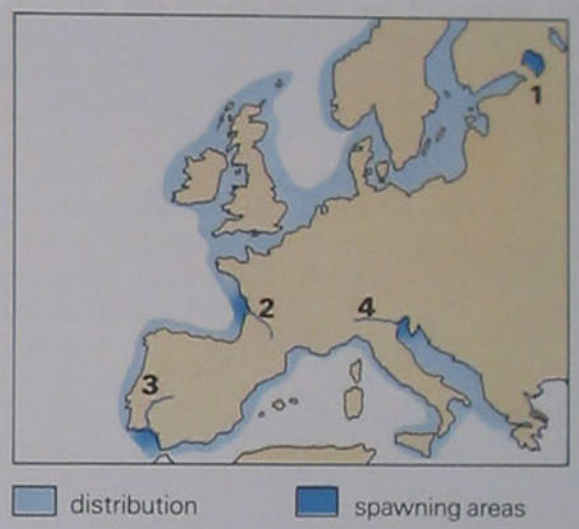
Invertebrate feeders Both young and adult sturgeon feed almost entirely on invertebrates. Young sturgeons in rivers eat nothing but bottom-dwelling invertebrates, chiefly the freshwater 'shrimp' (*Gammarus*), insect larvae and worms. In the sea, both young and old feed mainly on shrimps, crabs and molluscs, though very large sturgeons eat small fishes.

An examination of a sturgeon's head shows that, for such a large fish, it has a remarkably small mouth, well adapted for picking up food items buried in the sea-bed. Its mouth can be extended to form a mobile tube, rather like the tube on some vacuum cleaners. Just in front of the mouth are four slender barbels–highly sensitive organs used by the fish to discover buried invertebrates. The whole underside of a sturgeon's head is a mass of sensory cells–organs of touch and taste–designed to help it find the considerable quantities of food a fish of this bulk needs to survive.

Caviar and the future Sturgeons are, of course, the source of caviar, most of which is produced in the USSR from species other than the European sturgeon. Without the culture of sturgeons in the USSR the prospects for the survival of this fascinating group of fishes in the modern world would be bleak. River pollution, the building of dams and weirs, and heavy fishing have all taken their toll, and the various species of sturgeon are much reduced in numbers. It is essential that the stocks of sturgeon are maintained in the few rivers of western Europe in which it is still found to be breeding.

Distribution

The European sturgeon is found from the Baltic to the Mediterranean, but its breeding grounds are confined to the lower reaches of a few major rivers, though, there is reportedly a landlocked stock in Lake Ladoga (**1**). Sturgeons found in British waters are believed to come from the rivers Gironde (**2**) or Guadalquivir (**3**), but not the Po (**4**).



Below: Most people know the sturgeon as the source of caviar, which is made from the roe (the unshed eggs) of the female, preserved by salting. Almost all the caviar produced comes from the Black Sea basin in the USSR, where sturgeons are reared intensively, like these newly hatched fry in a hatchery at Volgograd, to the north-east of the Black Sea. Most Russian caviar comes from species other than the European sturgeon, though it makes perfectly good caviar.

BEE HAWKS: BUMBLE BEE MIMICS

Bee hawk-moths are among a number of otherwise defenceless insects which benefit from mimicking the well-protected stinging bumble bee.

Above: When the broad-bordered bee hawk (*Hemaris fuciformis*) hovers in front of a flower, its wings beating so fast that they are blurred, it can be mistaken for a bee. Such mimicry is probably a good defence against predators.

Below: Bee hawk-moth caterpillars can be found feeding during July or August. The broad-bordered bee hawk caterpillar shown here usually feeds on the foliage of honeysuckle, snowberry or bedstraw.

Two species of bee hawk-moths are resident in the British Isles, but they often go unrecognised even though, unlike most other hawk-moths, they are active by day. There are several reasons for this: first of all, both species are now uncommon and localised; secondly, they mimic tawny-coloured bumble bees and look remarkably like them when hovering over flowers; and thirdly, they are easily alarmed, often flying off at lightning speed before the casual observer has obtained a good view.

Bee hawk range The most widely distributed of the two British species is the narrow-bordered bee hawk. It frequents flowery fens, meadows and woodland glades and borders as far north as the north of Scotland and the Inner Hebrides. It also occurs over much of Ireland, notably in the bogs in the west and north of the country, and is found in the Channel Islands as well.

As its name suggests, it is distinguished from the other species–the broad-bordered bee hawk–by differences in the blackish borders or margins of its otherwise mainly transparent wings. These borders, seen when the narrow-bordered bee hawk is at rest, are much narrower than the broad, reddish-brown margins of the broad-bordered bee hawk.

Much less widely distributed in the British Isles, the broad-bordered bee hawk is unknown in Ireland and Scotland, and absent in England north of a line drawn from the River Mersey in the west to the Humber in the east. South of that line, it is found in woodland glades and borders in many parts of England and Wales.

Unfortunately, both species of bee hawk have become much less common and more localised since the mid-1950s, the broad-bordered tending to withdraw south-eastwards. Nobody seems sure of the reasons for the decline: heavy parasitism of the caterpillars has been blamed, but climatic changes since 1950 seem a more likely cause.

Identifying factors Apart from looking at the breadth of the wing borders–which is difficult when the moth is hovering in front of a flower with its wings beating so rapidly that they are blurred–it may be possible to tell the two species apart by looking at the yellowish-brown abdomen. There are two narrow black bands or belts on the abdomen of the narrow-bordered bee hawk, whereas the broad-bordered has a single, broad, reddish-brown band. The sexes of both species are alike.

Both species fly on warm, sunny days in May and June, usually in the mornings, although they may sometimes be seen on cloudy afternoons. They expend a great deal of energy flying actively in the sunshine and therefore need to replenish it constantly with nectar from flowers, the blossoms of bugle and rhododendron being especially attractive

Below: **Narrow-bordered bee hawk** (*Hemaris tityus*)

Below: **Carder bee** (*Bombus muscorum*).

Below: **Common bee-fly** (*Bombylius major*).

Right: **Narcissus fly** (*Merodon equestris*).

Left: **Hover fly** (*Volucella bombylans*).

Left: Large numbers of stinging or unpalatable insects, such as bees and wasps, share black and orange or black and yellow colour patterns. Predators recognise these colours immediately as a 'don't touch' signal and many harmless, edible insects benefit by copying this coloration to protect themselves. Bee hawks bear most resemblance to carder bees, but their swift, darting flight is very different from the deliberate, ponderous flight of these bees.

to both species. Their eyesight is good and they move with incredible speed at the slightest threat. They are further protected by their resemblance to bees, which is particularly valuable when they are at rest on foliage.

Camouflaged caterpillars The females deposit their spherical, bright green eggs singly on the undersides of the leaves of their food plants, usually while in flight. The broad-bordered bee hawk normally selects honeysuckle for egg-laying, but may also choose snowberry or some species of bedstraw. Devil's-bit scabious and, more rarely, field scabious are the choices of the narrow-bordered bee hawk.

The caterpillars of both species are mainly green, with spike-like horns at their tail ends. The narrow-bordered bee hawk caterpillar is generally slightly shorter and more slender than the broad-bordered. Its green body is covered with raised yellowish-white dots, and there is a yellowish stripe along each side of its back, with a border of purplish-red spots above. The caterpillar is also purplish-red underneath, and so is its horn.

The underside of the broad-bordered bee hawk caterpillar is more reddish-brown, edged with a yellowish line. The bright green upper parts become whitish-green along the back and the head is blue-green. Its slightly curved tail horn is rather colourful–lilac at the base, red-brown in the middle and tipped with dark brown.

The caterpillars feed underneath the leaves of the appropriate food plant in July and August and, although they are well camouflaged, their characteristic habit of nibbling rounded holes on each side of the leaf's midrib reveals their presence. When fully fed, measuring up to 5cm (2in) long, and ready to pupate, the caterpillars of both species turn reddish-brown. They wander away from the food plant and burrow just beneath the surface of the soil. Here they construct coarse but flimsy silken cocoons interwoven with earth and plant debris. Inside, the caterpillars eventually change into blackish-brown pupae, overwintering in this state. The moths emerge in spring, and only one brood is produced.

Above: Bee hawks can be difficult to find–the best method is to settle in a suitable spot where there are plenty of the flowers that they feed on, then wait for them to appear and feed busily, darting from flower to flower. Both species feed on nectar from bugle and rhododendron flowers, but the narrow-bordered bee hawk, shown here, also feeds on bird's-foot trefoil and lousewort and the broad-bordered on bluebell, ground ivy, honeysuckle and ragged robin.

The maiden flight

When the moths emerge in the spring, their wings are covered with a thin, loose layer of greyish-brown scales (right). These fall off when they take their first flight, leaving the characteristic large transparent areas (far right). This is a broad-bordered bee hawk, distinguished from the narrow-bordered by the single, broad reddish-brown abdomen band.

PLANTS WITH DEADLY BERRIES

A wide-ranging family which includes cultivated species such as many familiar vegetables and ornamental garden species, the potato family also includes the poisonous, sometimes deadly, nightshades which grow in woodland, hedges and on waste ground.

The nightshades and related species belong to a large family of plants, the Solanaceae, which includes tomatoes, aubergines, peppers and tobacco. The best known member of the family is the humble potato which originates from central and southern America, but is now a staple crop in many countries, including Britain. The wild British members of the family are nearly as well known, but not for any edible qualities. Quite the opposite in fact, for most of them are extremely poisonous, especially the several different species bearing the name nightshade.

Scrambling climber Woody nightshade, or bittersweet, is a woody perennial common in damp places in hedges, woods and waste ground throughout Britain, although it is rarer in northern Scotland.

A quick-growing plant reaching up to 1.8m (6ft) high, woody nightshade is not truly a climber, but tends to scramble up and over other plants. A curious feature of the species is that the leaves are always aligned to face the sun, while the flower clusters always face away from the leaves. The purple petals spread out when the flower first opens, and gradually curve downwards, completely away from the cone of bright yellow stamens in the centre of the flower.

The oval berries are green at first, ripening through orange to bright red and becoming almost translucent when fully ripe. They are produced in succession throughout the summer and early autumn, and a plant may bear fruit in all stages of ripeness while still flowering freely.

The plant has long associations with folklore, and a necklace of its berries was found in the tomb of Tutankhamen. Closer to home, the Vale of Furness in the north of England was known locally as the Valley of Nightshade because of the abundance of woody nightshade that grew there; it was even depicted on the ancient seals of the local abbey.

Garden dweller Black nightshade is a somewhat bushy annual reaching up to 60cm (2ft) in height. It is much less widespread than its woody relative, being rather rare in northern England, Wales and Ireland and absent from most of Scotland. Elsewhere, it is a successful weed and is widespread throughout much of the rest of the world. Common on waste ground, its frequent appearance in gardens has earned it the alternative name of garden nightshade.

It is rather a lacklustre plant with dull green foliage and small white flowers which are exactly like those of the potato. The flower clusters are unusual in that they arise from the sections of stem between the leaves instead of from the more usual position in the leaf axil. The berries are round and, like those of woody nightshade, are green when young but ripen to black.

A number of closely related species which are very similar in appearance have been introduced to Britain from various countries. For example, the South American species *Solanum sarrachoides* closely resembles black nightshade, apart from the berries which remain green when fully ripe. The orange-berried *Solanum pseudocapsicum*, the Jerusalem cherry, often sold as a pot plant under the name winter cherry, is also occasionally

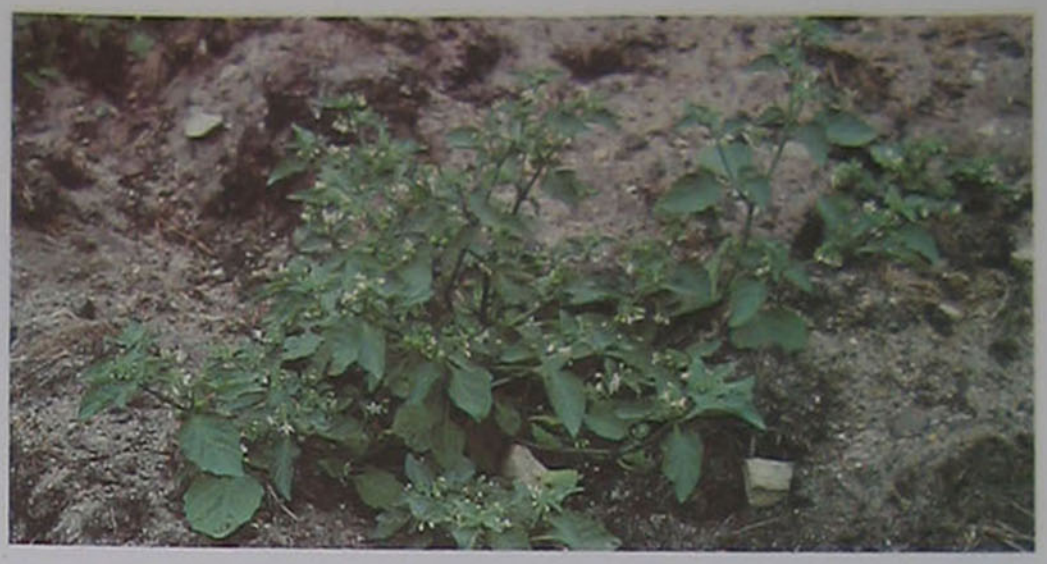
Above: The flowers of woody nightshade resemble those of the potato but the petals are purple, rarely white like those of its cultivated relative. Clusters of the colourful berries (below) are often seen at different stages of ripeness.

found growing wild in this country.

Satan's cherries Black nightshade is sometimes mistaken for the rarer and much more dangerous deadly nightshade or belladonna. Both plants have black berries, but there the resemblance ends. Deadly nightshade occurs on chalk and limestone soils in England and Wales, and is a rather bushy perennial, favouring shady spots in woods and thickets or near old buildings where it may reach a height of 1.5-1.8m (5-6ft).

It can be recognised by the lurid greenish-purple bell-shaped flowers which grow singly in the axils of the leaves, not in clusters like those of black nightshade. The large, coarse leaves grow in pairs, one member of the pair always being much larger than the other. The round, very shiny berries surrounded by the green lobes of the calyx are sometimes called Satan's cherries and are very attractive. This attractiveness is dangerous, since eating even one or two berries can be fatal to children. Birds, however, eat them without ill-effect, though they are too large for most species to manage.

The narcotic properties of the chemicals contained in the plant made deadly nightshade valuable as a drug plant, and it was once even cultivated in this country to supply the drug industry. Some of the old names, such as sleeping nightshade, attest to its uses, and it is still occasionally used in eye drops

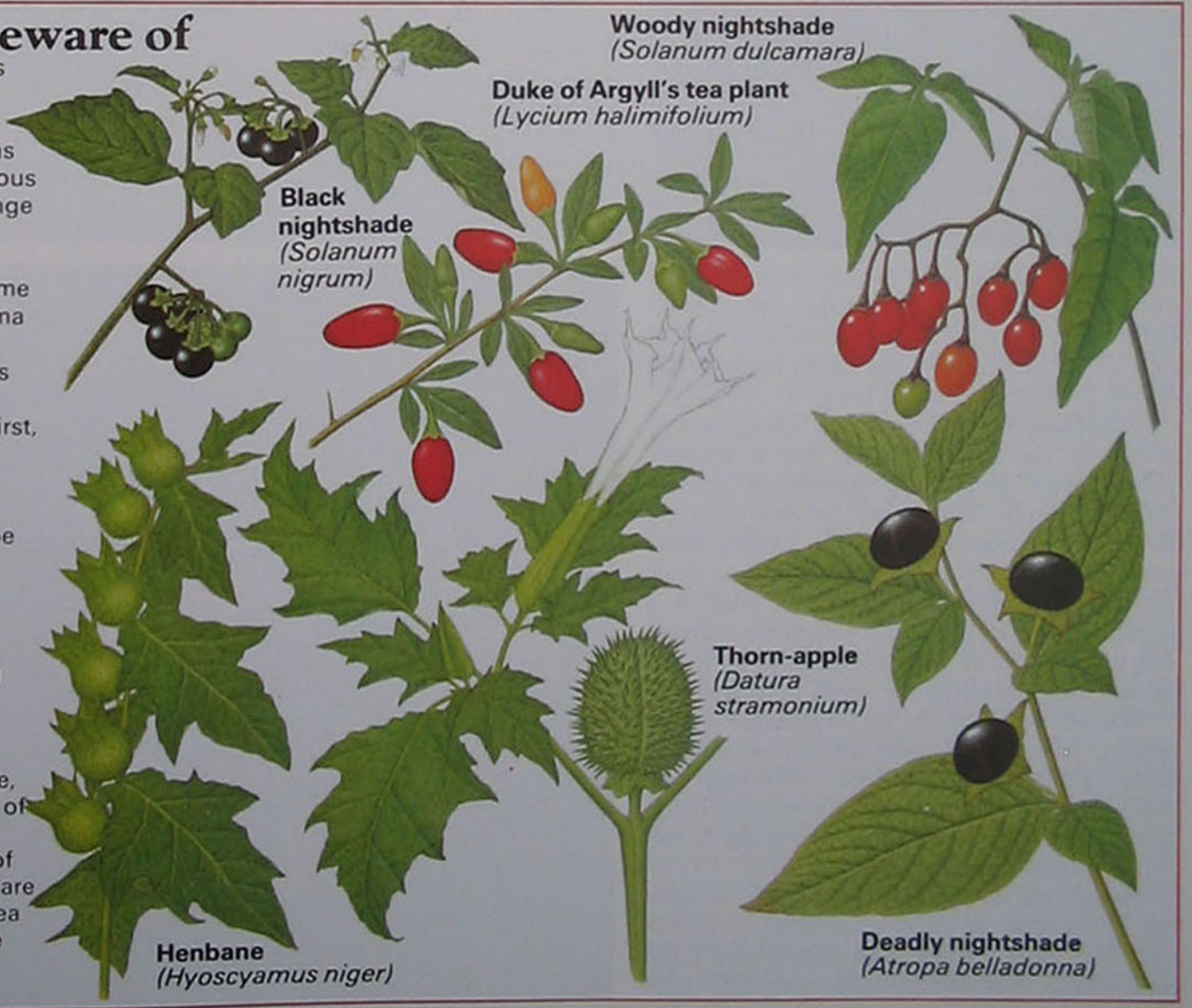


Above: Black nightshade is common on waste ground, and its frequent appearance as a garden weed has earned it the name garden nightshade. The small white flowers are exactly like those of the potato plant.

Right: The spiny seed capsule of the thorn-apple splits into four segments when ripe, releasing numerous seeds. Most cases of poisoning are due to accidental eating of unripe seeds, which taste sweet.

Berries to beware of

The harmful chemicals contained in these plants and berries are mainly alkaloid poisons which attack the nervous system. Symptoms range from giddiness and disturbed vision to paralysis and, in extreme cases, convulsion, coma and ultimately death. Woody nightshade has bittersweet berries—sweet to the taste at first, then bitter and unpleasant. Black nightshade berries are generally thought to be poisonous—those of deadly nightshade definitely are. In fact, all parts of this plant are deadly, containing the alkaloids atropine, hyoscyamine and solanine. The same is true of the thorn-apple, and of henbane, both of which contain scopalomine instead of solanine. Less deadly are the Duke of Argyll's tea plant berries—they are not poisonous.



Above: Henbane is found on sandy soils, especially near the sea or on waste ground. It can be recognised by its thick growth, the flowers which have prominent purple or violet coloured veins, and the often strong and unpleasant odour of the whole plant.

Left: The intriguing name of the Duke of Argyll's tea plant arose when a specimen, wrongly labelled as a tea plant, was sent to the Duke of Argyll in the 18th century.

for dilating the pupil of the eye. Italian ladies used it in this way in previous centuries to make their eyes more attractive, and this is said to be the origin of the Latin name *belladonna*, meaning beautiful lady.

Stupefying herb Henbane is easily recognised by its flowers which are a whitish yellow with prominent purple or violet-coloured veins. They grow in two rows on long, coiled, one-sided spikes. Unlike most other members of the family, henbane does not produce berries. Instead, the fruit is a capsule completely hidden within the tubular calyx. The top of the capsule acts as a lid, falling away to allow the seeds to escape.

The whole plant has an unpleasant odour which, in large concentrations, is said to cause giddiness and stupor. Although the leafy tops are used to produce a sedative drug, henbane is very poisonous and should be left strictly alone.

Dangerous alien The thorn-apple is variously thought to have originated in North America, South America or somewhere in the Old World. Wherever its home was, it has now spread to many countries. In Britain, it turns up fairly frequently as an alien, and sometimes manages to establish itself in waste places and cultivated fields. Probably the most beautiful member of the family, the thorn-apple has large, solitary white flowers measuring up to 8cm (3in) long, the narrow tube flaring into a trumpet-shaped bell. The flowers, which are strongly scented, open at night and are attractive to moths.

The thorn-apple takes its name from the seed capsule which is similar in size and appearance to a horse-chestnut fruit. The whole plant is poisonous, not just the seeds, although the effect of eating them is even more acute than in the case of deadly nightshade. For this reason, farmers uproot and burn the plant whenever it appears among their crops.

Harmless nightshades Not all members of the nightshade family are harmful. The tubers of the potato, for example, are our most common vegetable although the tomato-like berries are poisonous. The well known ornamental species, the Chinese lantern or cape gooseberry which occasionally escapes from gardens and establishes itself in hedgerows, produces no ill-effects. The single flowers resemble those of black nightshade but the calyx gradually enlarges, becoming papery and bladder-like, eventually turning bright orange to form the lantern of the plant's name. Within this lantern is a fleshy red berry.

The Duke of Argyll's tea plant, another harmless species, was popular as a garden plant with the Victorians, but has since fallen out of favour. However, it has made a home for itself on waste ground, old walls and waysides. A rather elegant shrub with arching, pearly grey stems armed with spines, it has funnel-shaped purple flowers, followed by egg-shaped, scarlet berries.

Below: The brilliant orange lanterns of the Chinese lantern (*Physalis alkekengi*) are not flowers. They appear in the late summer and contain a fleshy red berry.

KERRY: GIFT OF THE GULF STREAM

Kerry has been described as 'a world on its own'– an apt description when it comes to the wildlife inhabiting this unique corner of Ireland, since the mild, wet climate supports an unusual collection of plants and some strange animals as well.

Above: Killarney's famous and beautiful lakes. Among the oaks fringing the lakes can be found stands of the rare strawberry tree, as well as the more common yew and holly–all the gift of the mild climate created by the North Atlantic Drift.

Kerry, sited in the south-west corner of Ireland, is a land of great purple mountains (the highest in Ireland), glittering lakes, tiny tarns and three massive shoulders of rugged old red sandstone that thrust themselves deep into the Atlantic Ocean. The sea surrounding the coast of Kerry brings the welcome warmth of the Gulf Stream or North Atlantic Drift to the area, producing a mild, benign climate in which very hot summers, like cold winters, are exceptional and in which a soft, warm rain can be expected to fall every week of the year. With this climate there is a lushness in the flora of Kerry found nowhere else in Ireland, and some of the introduced species of plants have even spilled over into the wild countryside–New Zealand flax, balsam, fuchsia and many others mixing freely with the native flora.

Kerry's wild flowers The most interesting of Kerry's wild flora are the several native species peculiar, in the British Isles, to the south-west corner of Ireland. The flora of Kerry is based on two different geographical groups or elements. The slender naiad, pipewort and Canadian blue-eyed grass all belong to the North American element. The pipewort is a truly North American species, being unknown in the rest of Europe, except for small colonies in the west of Scotland, but some naturalists doubt that the blue-eyed grass is a native of Ireland, saying that it was probably introduced in 1847 along with American

Above: There is no difficulty in identifying the famous strawberry trees of Killarney when they are in fruit. When there is no tell-tale strawberry-shaped fruit, however, you can still recognise the tree by its shiny, dark green, serrated leaves, its white bell-shaped flowers and its flaking, fibrous, dull reddish brown bark. The leaves are evergreen, and the flowers, rather unusually for a tree, appear in October. The tree rarely grows more than 10m (33ft) tall.

grain during times of famine. Be that as it may, the North American element of Kerry's flora is generally regarded as of great antiquity, showing a pre-glacial arrival in Ireland.

The other important part of Kerry's flora is the Lusitanian element, which is even older than the North American, probably reaching Kerry long before the Ice Ages, when there was a continuous coastline between Kerry and the Iberian Peninsula. These plants include the rare arbutus or strawberry tree, the large-flowered butterwort or bog violet which bears a massive, intensely blue flower at the top of a delicate, thin stalk and has light green, insect-catching leaves, and a saxifrage known as St Patrick's cabbage or, elsewhere, as wild London Pride.

There is also the Kerry lily, whose white flowers do not appear before the middle of June and are gone by the end of July, the lovely lady's tresses orchid, the frog, spider, butterfly and fragrant orchids, the Irish spurge, the lush royal fern which grows tall enough to act as a hedge between fields, and the bog cotton which grows in the wetlands bordering the famous Ring of Kerry. But perhaps the most attractive aspect of Kerry's flora is the series of ancient moss-covered oak woods that have persisted almost unchanged down the centuries.

Some of the currents in the North Atlantic Drift bring more than just warm water to the coasts of Kerry. The seeds and fruits of tropical American plants are carried in the ocean currents from the Caribbean and can float buoyantly on the water surface for up to two years. These seeds, known as 'sea beans', are sometimes washed ashore on the Kerry coast, especially after a gale from the south-west.

Cold-blooded animals A number of animals are peculiar to Kerry, including several species of spiders and insects that are known only to specialists, and also the unique spotted slug of Kerry; in the British Isles this slug is found only in Kerry and Cork, and in Continental Europe it is confined to the Iberian Peninsula.

Right: Tomies Wood, near Killarney—the mild climate and heavy rainfall create exceptionally humid conditions which are ideal for the abundant growth of mosses seen here. Some of these mossy oak woods in Kerry are extremely old, but today they are threatened—in particular by the all-engulfing spread of the introduced *Rhododendron ponticum* which thrives in woodland habitats at the expense of the native plant species.
The mildness of Kerry's climate means that many tropical shrubs from South America and Australia can be grown in the open. Examples of this are the glade of Australian tree-ferns established at Glanleam on Valencia Island, the biggest Embothrium (a South-American tree), growing on the same island, and a Chilean myrtle known as 'Glanleam Gold'.

The only Irish species of toad is the natterjack, which is confined to small areas at the head of Dingle Bay around Rosbegh, Castlemaine and Lough Caragh, although an attempt was made to give it a wider distribution–unfortunately without success. It is a matter of some dispute as to whether the natterjack, with its isolated and limited distribution, is a native or introduced species.

Irish mammals There is, however, little doubt about the discovery in 1964 at Listowel in Kerry of a mammal new to the Irish fauna–the bank vole. The rate of its recent spread into such counties as Cork and Limerick would suggest a fairly recent introduction, but whether it was done deliberately, or occurred by accident, is impossible to say.

Ireland is well-known for its own forms of two species of mammals found on the British mainland–the mountain hare and the stoat. Both animals are plentiful in Kerry. The Irish hare is a dark, russet red, while the Irish stoat differs from the British species in being almost a third smaller, darker and with less white markings on its underparts. The pine marten, too, is probably more common in the west of Ireland than elsewhere in the British Isles, and tales of pine martens removing bin lids for their contents are frequent.

Perhaps the most important mammal in Kerry, however, is the red deer. Ireland's ancient species of wild red deer once roamed the whole of the Irish countryside, but down

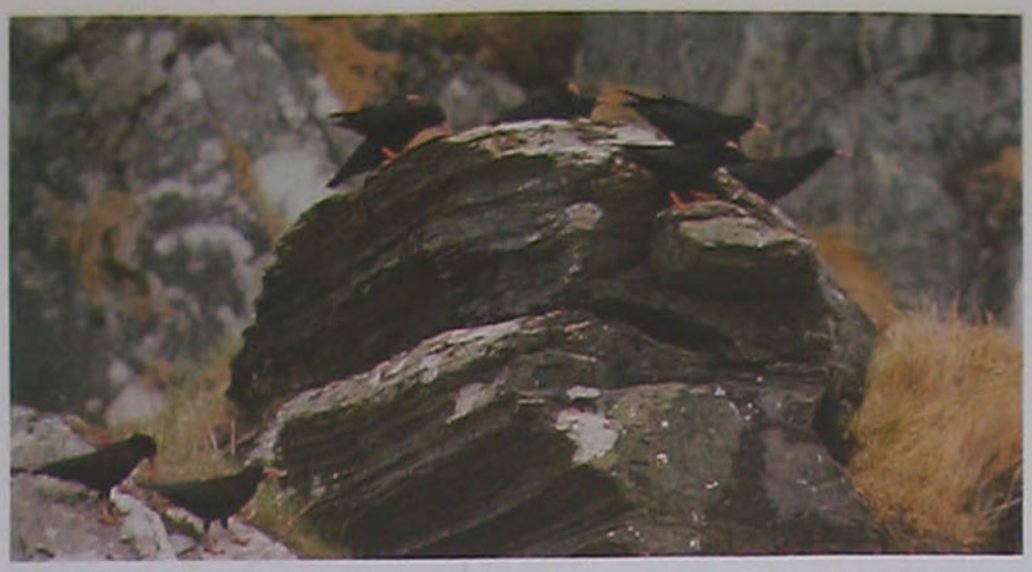
Above: A red deer stag in Killarney's mountains–just a remnant of the large herds of wild red deer that once roamed throughout Ireland. Hunting and harassment have accounted for many of the deer.

Right: The spotted slug of Kerry–found only in Cork and Kerry.

Below: The blue-eyed grass belongs to Kerry's 'North American' group of plants, the others shown here to the 'Lusitanian' element.

Kerry's rare plants

St Patrick's cabbage (London Pride) | Blue-eyed grass | Irish spurge | Kerry lily



Above: Choughs roosting on a cliff ledge. The sea cliffs and mountain ledges of Kerry are much favoured by these birds which, in other parts of Ireland, are decreasing in number.

Left: Another rarity to grace south-western Ireland is the large-flowered butterwort, or bog violet.

Below: The three great peninsulas of Kerry are the westernmost parts of Europe. The high mountains are bare and windswept, and much of the lower land is acid peat, but the valleys are lush with vegetation.

the centuries it was hunted and harassed until today only a very few remnants can be found in the mountains above Killarney. Stags from Windsor Great Park and from Scottish deer forests have been introduced into this herd, no doubt improving the size of the deer, but decreasing the purity of the old line somewhat. Today the purity of the blood of these ancient wild deer is threatened even more, for the herd shares the same mountains with feral herds of Japanese sika deer.

The lakes and rivers of Kerry are full of fish, but they are also the habitat of American mink, which have escaped from fur farms and become established in feral populations that persist round the edges of such lakes as Lough Currane near Waterville. On one of the islands in this Lough, terns have bred for many years, but have now deserted the site because of the presence of the mink.

The birds of the air The site and situation of Kerry, and the abundance of reed-fringed lakes, marshes and mudflats, means that it is a great wintering area for wildfowl and waders. From the light-bellied Brent geese which feed on eel grass in Tralee Bay, to the American waders which seem to make Akeagh Lough their first port of call, Kerry is rich in winter birds. And, though the handsome chough, with its red beak and legs, has decreased throughout Ireland as a whole, you do not need to go far in Kerry without hearing its distinctive screaming call.

But it is the vast multitudes of seabirds, their breeding colonies sited on the many famous islands off the south coast, which make Kerry a bird-watcher's paradise. The most important sites for the seabirds are the cluster of islands around Great Blasket Island, the Skelligs and Puffin Island. Here great colonies of Manx shearwaters, storm petrels, fulmars and auks breed in huge numbers.

Perhaps the most famous of all the Kerry islands is the cathedral-topped island of Skellig Michael. It has a long history of monastic settlement; the monks' old cells, which crowd the cushions of sea pink 600m (nearly 2000ft) above the wild waters of the Atlantic, can be reached only by a stone stairway made 1600 years ago. As you walk up this old stairway, the sound of each footstep produces soft crooning noises from the storm petrels that have chosen to breed beneath each step.

Rabbits, reputedly descended from Belgian hares introduced to the island a century or more ago to provide meat for the lighthouse men in hard winter gales, have built extensive warrens on the island and caused some of the old beehive-shaped cells to collapse. This is unfortunate since the storm petrels breed between the walls of these beehive cells. It is estimated that 40,000 pairs of storm petrels breed on this one island alone; in fact, it is believed that the Kerry Islands hold the largest colonies of this species in the world.

SUMMER-BLOOMING SPEEDWELLS

Grassy banks, woodland and watersides are the best places to find the attractive 'bird's eyes' or speedwells. Although the flowers are characteristically blue, with a white 'eye', some are pink or white, making them easier to identify.

Above: The germander speedwell (*Veronica chamaedrys*) is probably our most familiar speedwell species, the deep blue flowers with a prominent white eye often carpeting hedgebanks and grassy places. There may be as many as 20 flowers on a single flower head, and they are in bloom from March to July. A common name shared by many speedwells is 'bird's-eye', the small blue flowers supposedly resembling birds' eyes among the grass.

Speedwells belong to the same family as figworts and foxgloves – the Scrophulariaceae – but their flowers differ from other members of the family in Britain in that they have only four petals, not the usual five. The upper petal of a speedwell flower, which is slightly larger than the others, represents two petals that have become joined. There are over 20 species in the British Isles, many of them rather similar, and a close look may be needed to identify them.

Shades of blue The familiar deep blue flowers, each with a prominent white eye, belong to the germander speedwell. Buxbaum's speedwell has similar, but brighter, blue flowers without such a conspicuous eye, while thyme-leaved speedwell has almost white flowers with violet lines on all but the lowest petal. The colour variation continues in ivy-leaved speedwell, which has small lilac flowers, and in pink water speedwell where the flowers are, as the name suggests, pink.

The differences between the species are even more apparent on close observation. Some speedwells, such as the ivy-leaved speedwell, have flowers borne singly at the base of a leaf, while in others the flowers are borne in elongated heads. Species such as the brooklime have a number of flower heads towards the end of the stems, each one arising from the base of a leaf, while such species as the spiked speedwell bear numerous flowers in a long spike forming the tip of the stem.

Speed-you-well The flowers' common name may refer to the old parting saying 'Speed-you-well' or 'Speed well', which is equivalent to 'Farewell'. Indeed, in Ireland the speedwell was once sewn on to clothes to protect travellers against accidents. The association between parting and the speedwell probably arose from the way that the petals fall quickly from the plant, often as soon as it is picked. Alternatively, the name may refer to the plant's curative powers, for it was used as a remedy for ailments as diverse as coughs and leprosy, and in the healing of wounds.

Water speedwells Many of the speedwells grow in a wide range of habitats, but brooklime and the marsh, water and pink water

speedwells are found in very wet places. These range from marshy soil to the shallow water of ponds, streams or the sides of rivers and lakes.

All four are more or less hairless plants and have a similar arrangement of flowers, arising in elongated heads branching from the main stems. The pale pink marsh speedwell is the most easily distinguished as its flower heads are on alternating sides of the stem. As its name suggests, it can be found on marshy ground in wet meadows and bogs, although it sometimes occurs in shallow water.

The flower heads of the remaining three species arise in pairs on opposite sides of the stems. Brooklime, often found at the water's edge, has broad, rather blunt leaves, each with a distinct stalk at its base. The two water speedwells are very similar in appearance and often confused with each other. Both have upright stems, and rather narrow, pointed leaves which clasp the stem at their base. However, the pink flowers of the pink water speedwell are a distinguishing feature, as is the position of the seed capsules when they develop. The stalks of the developing seed capsules of the pink water speedwell spread out at right angles to the flower head stem, while those of the water speedwell are angled towards the tip of the flower head.

Grassland and wasteland species Four annual speedwells – ivy-leaved, Buxbaum's, grey and field speedwell – grow in disturbed soil. They are found in gardens, farmland and other places where the ground has been cleared – usually by man's activities.

They form a characteristic group among the speedwells, with stalked flowers borne singly at the base of the leaves, which are all very similar in size and shape. Those of ivy-leaved speedwell are, as its name indicates, rather like those of an ivy, with five to seven lobes. The leaf margins of the other three species have small, rounded teeth.

The flowers vary in colour and size. Those of ivy-leaved speedwell are tiny and may be lilac or white, with heart-shaped sepals. Buxbaum's speedwell has larger, bright blue flowers measuring up to 12mm ($\frac{1}{2}$in) across.

Above: The two species of speedwell most commonly confused with each other are the germander speedwell, shown here, and Buxbaum's speedwell (*Veronica persica*), shown below left. Although the two are similar shades of blue, Buxbaum's speedwell very often has a much paler lower petal. Another distinguishing feature is the structure of the flower head – Buxbaum's speedwell produces a single, long-stalked flower while the flower spike of germander speedwell consists of several blooms.

Right: The spiked speedwell (*Veronica spicata*) is easily distinguished from other speedwells by its spikes of blue-violet flowers which appear from July to September. However, it is a very rare species, found only in East Anglia and a few counties of western England and Wales, where it is protected by special legislation, making it illegal to take any part of the plant from the wild.

Above: **Water speedwell** (*Veronica anagallis-aquatica*). Flowers June-Aug.

Above: **Common speedwell** (*Veronica officinalis*). Flowers May-Aug.

Above: **Rock speedwell** (*Veronica fruticans*). Flowers July-Aug.

Above: **Marsh speedwell** (*Veronica scutellata*). Flowers June-Aug.

Above: **Thyme-leaved speedwell** (*Veronica serpyllifolia*). Flowers Mar-Oct.

The blue flowers of the grey speedwell (its name refers to the leaf colour), and the white or pale blue flowers of the field speedwell, are much smaller, measuring only 6mm ($\frac{1}{4}$in) across.

Buxbaum's speedwell was first recorded in Berkshire in 1825, having been introduced accidentally from western Asia. It is now widespread throughout the country, and is thought to be our most common species in gardens and on waste ground. Ivy-leaved speedwell and grey speedwell are most common in southern England and rare elsewhere, while field speedwell is scattered throughout the British Isles.

Annuals and perennials The four species described above are all annual, as is the wall speedwell. This species often grows as a weed, but can also be found on heath and grassland. It can also take root in crevices in rocks and walls, growing well in dry, bare places. It has small blue flowers on very short stalks and the leaves become much smaller towards the upper part of the stem.

The many perennial species of speedwells include the germander, common, wood and thyme-leaved speedwells. The small, pale flowers of the thyme-leaved speedwell are borne towards the tips of the main stems. It is a common species on various types of grassland and also grows in damp spots in gardens.

Common speedwell is another plant of grassland, although it prefers drier soils, and it is also found on woodland margins. The individual lilac flowers are carried on very short stalks and packed rather closely in an elongated head.

Germander speedwell is another grassland species, although it sometimes appears in woods as well. It has as many as 10 to 20 blue flowers in each flower head, and paired, often stalkless, leaves.

The wood speedwell bears some resemblance to the germander speedwell, but it has lilac flowers – usually five or less in a head – and paired, stalked leaves. It is common in woodland, usually on damp soils.

Shrubby speedwells Some perennial speedwells are slightly woody at the base – the rare rock speedwell, for example, a species of high mountains in eastern Scotland. No speedwells are true shrubs, however, but there are some plants known as shrubby speedwells, which were formerly included in the same genus as the British speedwells. These are the hebes, originating from New Zealand but cultivated in gardens here, where they grow vigorously in our relatively mild, damp climate. The plants produce long heads of flowers and set abundant seed, seedlings appearing around the parent plants and often outside the confines of the garden. In this way, several species have become naturalised. The hybrid *Hebe* × *franciscana* is often planted in seaside towns because of its tolerance of salt-laden winds and it is now naturalised over miles of cliffs.

Above: An illustration of the diversity of colours and forms found among the speedwells if you examine them closely. Although many species are the familiar, characteristic blue, the flowers of others may range from almost white with lilac veins, to the red-eyed, bright blue flower of the rare rock speedwell. In some species the flowers are borne in long spikes, while in others they appear on single stems.

Above: Some speedwells favour watery habitats, growing by ponds and streams and in other wet places. The pink water speedwell (*Veronica catenata*) produces small spikes of pink flowers from June to August. The attractive brooklime (*Veronica beccabunga*), shown left, flowers in similar habitats from May to September. The lower part of its stem, often creeping, rooting and rather fleshy, may extend out into the open water and is sometimes partly submerged.

NOMADIC HUNTERS OF THE NORTH

Food is first in the short-eared owl's life–a life totally governed by the availability of field voles, its main prey. Not only is the size of its brood influenced but also its territory, lack of voles often forcing the owl into a nomadic existence.

Above: In flight the short-eared owl is identified by its long wings which have a dark 'carpal patch' at the angle of the wing.

Opposite: This species is not often seen in trees, preferring to perch on posts or even on the ground.

Below: The owl's short 'ears', which can be raised or lowered at will, have nothing to do with hearing, but are thought to convey its mood–fear, excitement and so on–to other owls.

The short-eared owl is one of the most widespread of the world's 133 owl species. Found throughout most of Europe and North America, the northern half of Asia and the southern half of South America, it has even made its way to a dozen remote oceanic islands, such as the Galapagos Islands, 965km (700 miles) west of Ecuador, and Hawaii in the very centre of the Pacific.

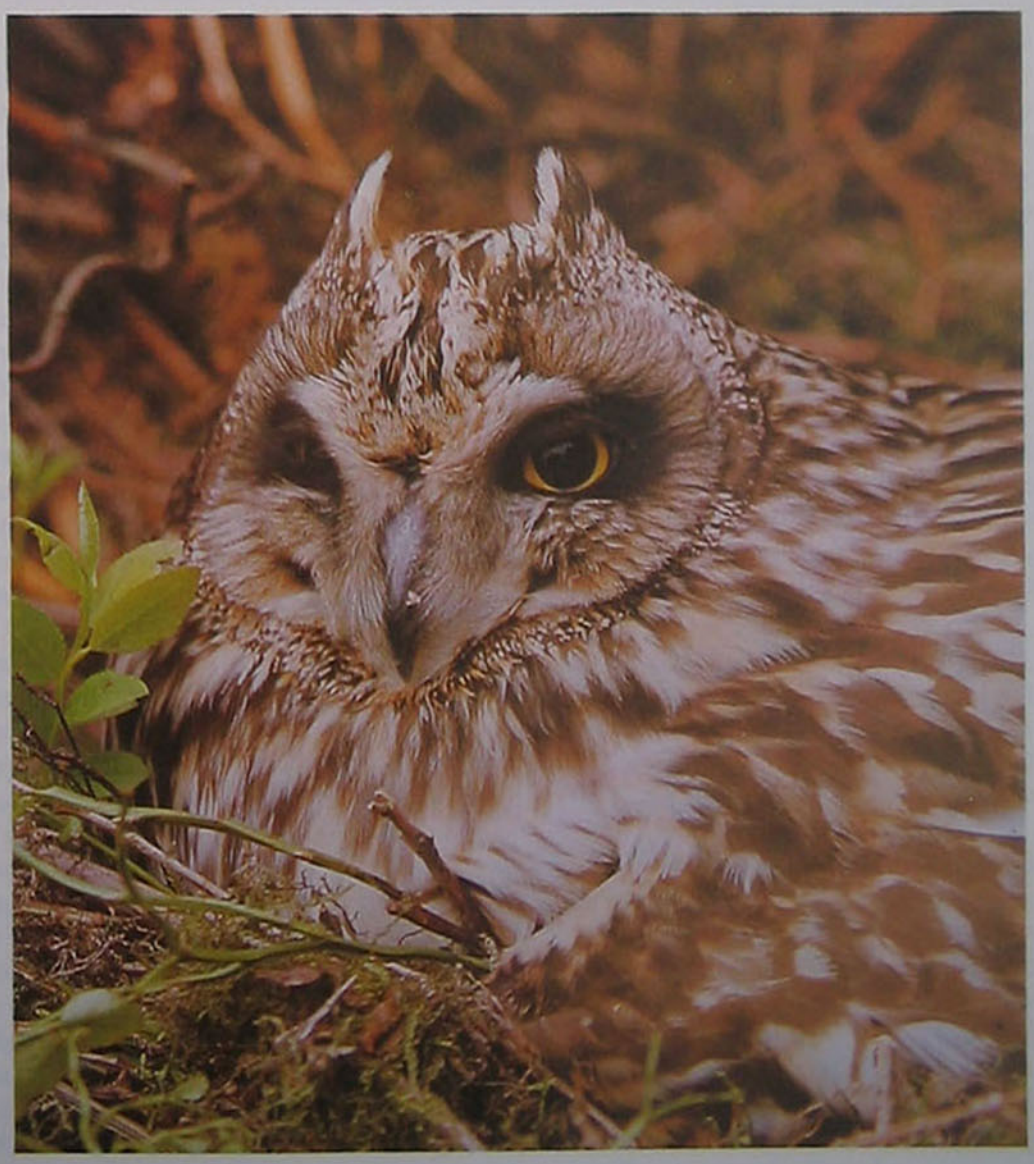
Despite this enormous range, the short-eared owl is not a common bird in Britain–barn, little, tawny and long-eared owls all have much larger populations. Although it has been breeding in Scotland, Wales and northern England for many years, it has only recently colonized the coastal marshes of East Anglia and Kent. Nevertheless, since it is primarily a day-time hunter, and since the population is augmented by migrants from the Continent in winter, it is not difficult to find. You may come across several of them together, roosting on the ground, or floating like giant moths over the wild and treeless terrain they tend to favour.

Bouncy flight Extensive tracts of moor, bog, heath, rough grass, dunes and coastal marsh are ideal habitats for the short-eared owl, quite unlike those of its relative, the long-eared owl which is a rarely seen, highly nocturnal forest dweller. Gliding just a couple of feet above the grass, with slightly raised, extraordinarily long, outstretched wings, you might well mistake one for a harrier, were it not for the large, round head which could only belong to an owl. Compared to the weight of the body, the wing area is very large and the resultant buoyant, rather bouncy, flight is characteristic.

When seen flying close-to, the striking appearance of this owl becomes obvious. The black-centred, pale yellow eyes are each highlighted by a ring of smoky black feathers which merge into the pale buffs and greys of the facial discs. Almost hidden among these feathers, like a secret weapon, is the cruelly hooked, razor-sharp beak.

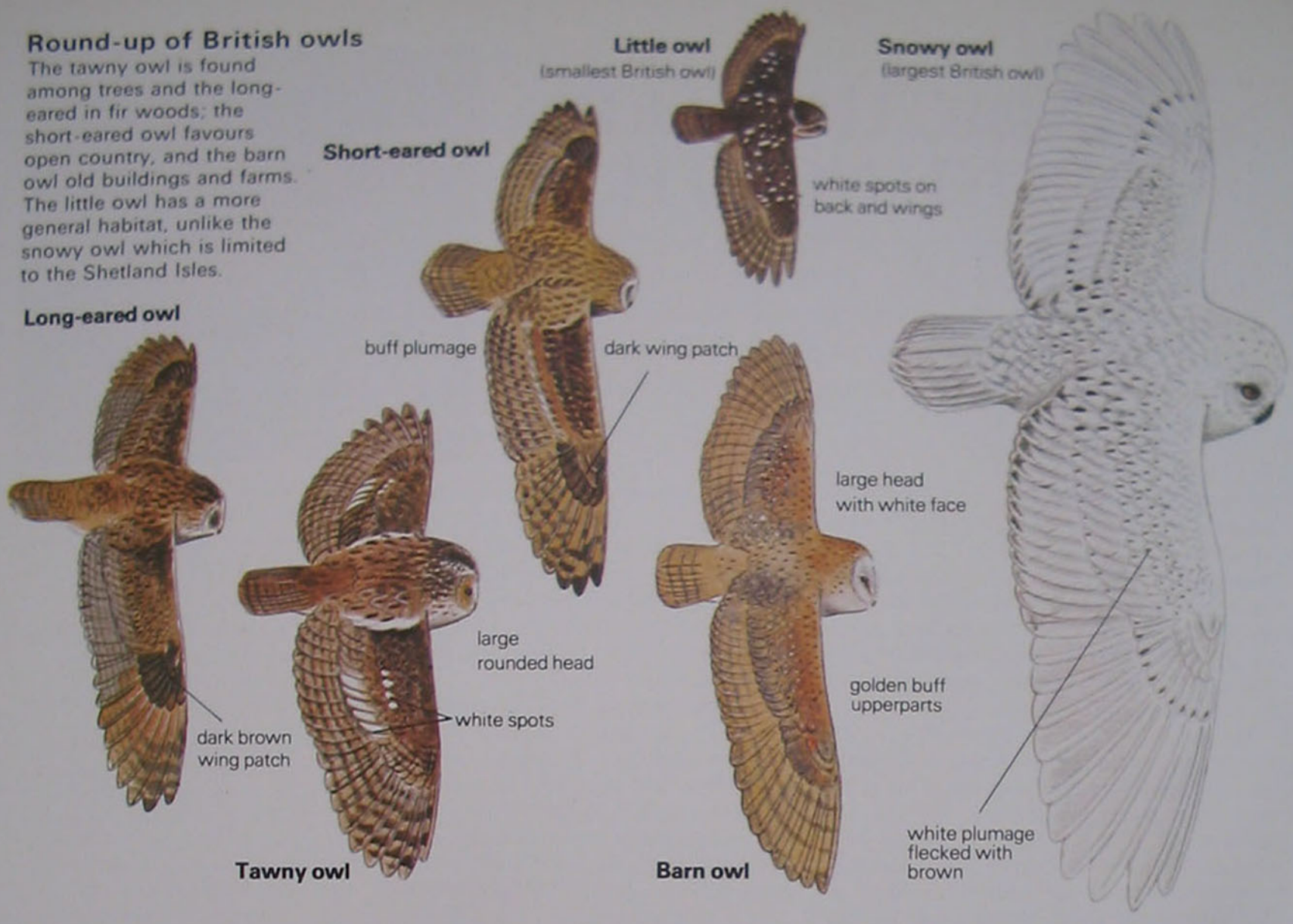
The back is mottled and streaked with buff and brown, while the wings are a similar colour but with white spots. In contrast the underparts are pale, boldly streaked with brown on the breast but fading to fine, rather delicate streaks on the belly. Like other owls, the thick and muscular legs and feet are covered with tiny white feathers right down to the long, curved, needle-sharp claws. In flight the wings and tail are noticeably barred and there is a dark patch at the angle of the wing–the carpal patch.

Cunning hunters Short-eared owls use a 'glide, surprise and grab' hunting technique which makes them proficient hunters, each one able to catch several thousand voles a year. Using eddies and upcurrents in the wind, they often glide for considerable distances without a single flap, their soft, well-padded plumage ensuring totally noiseless flight, so



Round-up of British owls

The tawny owl is found among trees and the long-eared in fir woods; the short-eared owl favours open country, and the barn owl old buildings and farms. The little owl has a more general habitat, unlike the snowy owl which is limited to the Shetland Isles.



Below: Young short-eared owls are a comical sight, covered in white and later grey down, quite unlike their parents. Fledging takes 20 to 30 days but they do not stay in the nest all this time. After only a fortnight they venture out and hide in the surrounding vegetation, even though they cannot yet fly. This behaviour makes it more difficult for predators to find them.

that the unsuspecting vole gets no warning.

Their prey-detection equipment is no less ingenious. The forward-facing eyes give superb binocular vision for accurate judgement of distances, while the discs of feathers surrounding each eye focus the slightest rustle on to enormous, highly sensitive ears, so that even in the gloom of dusk, when owls (and voles) are most active, they can pinpoint the position of their prey with ease.

Nomadic existence It is often thought that predators control the numbers of their prey. This is not true – the opposite usually applies, as is the case with the short-eared owl, whose own life is dominated by the field vole which forms most of its diet. Since vole populations are far from stable, the fortunes of the owl and the strategies it adopts vary dramatically from month to month and from year to year.

Apart from hiding among long grass, the voles' only defence against short-eared owls is prolific breeding. During the summer they produce litters at the rate of five young every seven weeks. As the youngsters can themselves breed when about six weeks old, vole populations often reach plague proportions (on average about once every four or five years).

Evidently short-eared owls thrive during these vole plagues, especially since the voles become noisy and may eat much of the grass that would otherwise conceal them. This has two main effects: first, owls from many miles around flock, as if by magic, to the bountiful food supply, and secondly, the owls capitalise on the easy pickings by 'breeding like voles' – laying 10 or more eggs (14 is on record) and sometimes having two broods in a season. The glut is usually short-lived. In such crowded conditions voles stop breeding and this, combined with the heavy predation, results in a population crash. Consequently, in the year following a vole plague, any owls that have not moved on find the larder seriously diminished and may not breed.

The most dramatic demonstration of the nomadic nature of the short-eared owl comes from Vancouver airport in Canada. Here, the neatly mown grass bordering the runways

Above: This female is adopting an almost horizontal stance—a characteristic peculiar to short-eared owls. Breeding starts from April onwards when the female lays her rather conspicuous white eggs in a hollow among tall grass, heather, gorse or brambles, where there is some shelter. She is a good mother, incubating for hours at a time and leaving the nest only when absolutely essential. Throughout the 24 to 28 days of incubation, and while the chicks are young and still need brooding, her mate brings food for the whole family. Their diet consists mainly of field voles although other rodents, insects and even small birds may be brought to the nest by the male.

Short-eared owl (*Asio flammeus*); resident bird joined by migrants from Continent in winter. Found mainly in Scotland, Wales and north of England where it favours open country. Length 38cm (15in).

attracted flocks of roosting gulls and waders which became a serious bird-strike hazard to aircraft. In an effort to remedy the situation the authorities let the grass grow longer, hoping it would force the birds to roost elsewhere—it worked. However what the authorities didn't bargain for was the vast influx of owls which came to hunt the newly thriving vole population breeding in the long grass. Over 500 owls were trapped and taken elsewhere in only three years.

Family life In spring the male is seen displaying high over his territory, booming out his song at the same time. From a lofty position he twists his wings down and back to meet behind his tail and rapidly claps them together several times, meanwhile plummetting several feet towards the ground.

Following the courtship and mating procedure, the female lays her eggs in a sheltered hollow on the ground, at any time from April onwards. During incubation she rarely leaves the nest—her mate brings all the food needed for her and the young family.

While the owls can, to a certain extent, judge the amount of food available and vary the size of their clutch accordingly, they also have an additional safety mechanism which ensures that the maximum number of healthy young will fledge. The female lays eggs at two-day intervals and incubates right from the start, ensuring that the chicks also hatch at two-day intervals. Then, if the adults have judged the food supply correctly there will be sufficient for all the family—from the oldest (and strongest) to the youngest—but if they overestimated the number of voles, only the youngest chick dies. The logic for this strategy is very simple: it is better to raise a few healthy nestlings than many weaklings.

Fledging takes 20 to 30 days depending both on the number of voles and the number of owlets—the more food there is to go round, the faster the owlets grow and the sooner they fledge. Initially the mother tears up food for the young, but before long one vole is just one mouthful. They cough up the indigestible bones, teeth and fur in a pellet about 5cm (2in) long and 2cm ($\frac{3}{4}$in) in diameter. Analysis of these pellets shows that several small rodent species supplement the field vole diet, on the Isle of Man brown rats being particularly important. On the coast, particularly in winter, short-eared owls also catch birds such as finches and waders—even in flight—showing a surprising turn of speed and agility when necessary.

Today, when so many of our native birds are declining, it is good to report that short-eared owls are probably more common now than at any other time this century. One reason for this is that young forestry plantations, now a common sight in many upland areas, have proved to be an excellent habitat for them. While the trees are small and the grass is long, voles and owls thrive.

THE WORK OF A TREE NURSERY

Most trees growing in Britain today—from urban park or garden trees to the vast acres of Forestry Commission plantations—originated in a tree nursery, where young plants are raised and tended to give them the best possible start in life.

The job of a tree nursery is simply to produce large numbers of young trees, either by growing them from seed or by propagating them. A few of the larger private nurseries stock hundreds, or even thousands, of different species but most produce a fairly limited range to suit the demands of their customers. For example, Forestry Commission or other forestry-orientated nurseries produce only the type of tree required by the forestry industry—mainly small conifer transplants. On the other hand, Local Authority nurseries and private wholesalers confine themselves mainly to the more popular ornamentals seen in private gardens, parks and landscaping schemes.

Pros and cons There are several advantages in planting nursery-raised stock. The nurseryman can choose his stock for particular qualities and he can protect it from the unwelcome attentions of birds and animals, and from pests and diseases. When breeding trees, he can select superior individuals to improve the genetic quality of the next generation. He can also grow the trees in straight lines, making them easier to care for and weed, which in turn leads to stronger-growing, healthier young plants.

In the case of forestry planting, however, using nursery stock does have disadvantages. Planting large areas can be extremely expensive. Also, by breeding nursery trees for certain qualities, the nurseryman may breed out other characteristics which are desirable for the well-being of the wildlife the plantation is expected to support.

Nursery stocks There are a variety of different ways in which a nurseryman cultivates his stock, depending on the species of tree and its ultimate purpose. The principal types are seedlings, transplants, whips and feathers, and standards.

Seedlings are raised from seed in a specially prepared seed-bed, usually for one or two years, though sometimes for three. They are not usually planted directly into a forest because they lack sufficient food reserves and a well-enough developed root system to enable them to survive in the hostile environment of a forest site.

The most popular stock for planting out into forests is transplants—seedlings that have been sown and replanted elsewhere to produce a plant with a sturdier root system. The act of transplanting severs the seedling's roots, which causes the plant to grow more roots and also slows down its growth of foliage to redress the balance. This produces a sturdier plant that has greater food reserves and is more likely to survive in a forest. Another advantage of transplanting is that it allows the nurseryman to correct the spacing between plants.

By growing on seedlings or transplants for a further year or two, the nurseryman can produce whips, which are long thin branchless plants about 1m (3ft) tall, or feathers,

Above: The Hillier nurseries near Winchester stock more trees, of a greater number of species and varieties, than any other nursery in the world—roughly 1¼ million specimens of about 8000 species and varieties. Formed more than 100 years ago, the nurseries together cover about 180 hectares (450 acres) and have a staff of 250. Most of their sales are to Local Authorities and development corporations, though they also have several retail outlets and a mail-order system.

Right: A young pendulous form of swamp cypress—too young as yet to show its weeping habit. This tree will eventually be sold for an amenity planting.

which are usually taller than whips and have small side-branches along the stem. Both types of tree are used mainly for landscape and ornamental plantings. Standards are larger plants, about 2.5-3.5m (8-11ft) tall, with a clear stem up to 2m (6ft) high and a branched head.

Methods of cultivation Much nursery stock is raised from seed. The method is relatively cheap and quick, but there are disadvantages. The quality of the seed may be uncertain and the crop has a variable appearance; this may be an advantage in forestry, where some variability in appearance helps to break up the monotony, but is not usually desirable when planting an avenue.

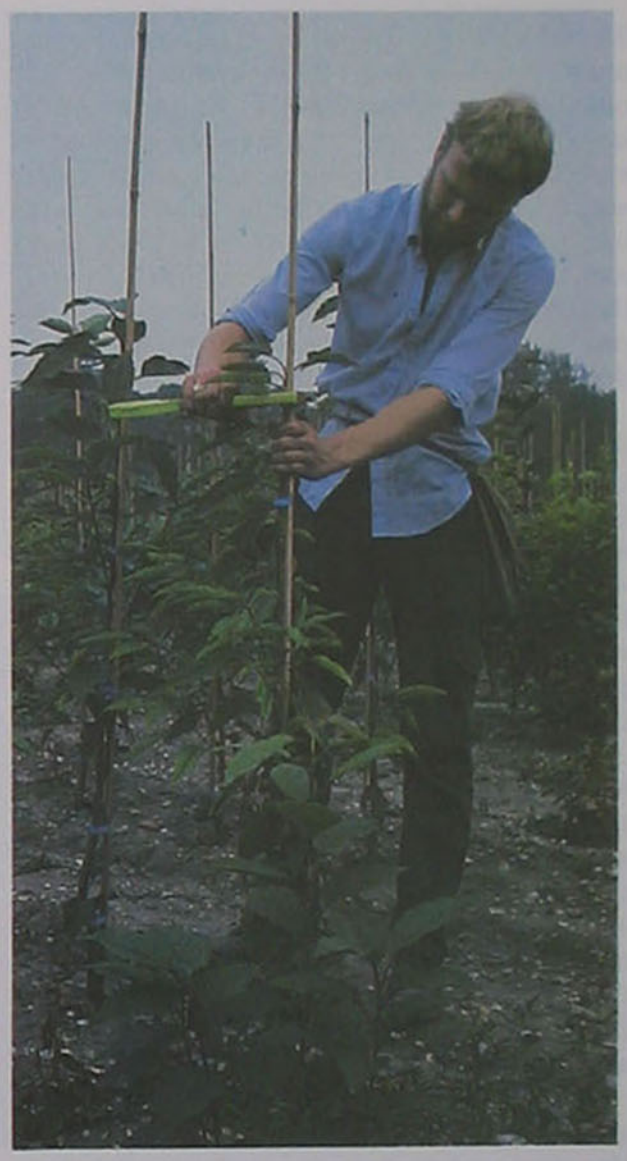
There is also the problem of dormancy. The seeds of a few species, such as birch, will germinate immediately after ripening, but most undergo a period of dormancy first, waiting until the spring before they germinate. Nursery-sown seed has to be specially treated to simulate the change of seasons and induce germination.

As well as raising trees from seed, there is a whole range of vegetative techniques for propagation. A well-known method is to take cuttings. There are two types of cutting: hardwood and softwood. Hardwood cuttings are taken of mature shoots during the autumn or early spring when the cutting is not putting on foliage and so is best able to grow new roots. Softwood cuttings are taken from shoots that are not yet mature. They are taken in the summer when the cutting is in leaf. Taking softwood cuttings is not a common technique for propagating trees.

Other techniques include layering, grafting and budding. In layering, the shoot of a tree is bent down to the ground and covered with soil. After a year or two, the shoot forms roots beneath the soil and it can be severed from the parent to form a new plant. Grafting and budding cover a range of techniques in which a small segment of tree called the scion, complete with bud, is attached to another tree, the rootstock, so that the cambium in the two parts is joined. (The cambium is the layer of cells between the inner wood and the bark where growth occurs.) Since the scion is attached, via the cambium joint, to the roots of the rootstock, it makes new growth.

Modern methods One recently developed technique for propagating plants has just started to be used for trees. The method is called micropropagation. Small groups of cells, or even a single cell, are taken from part of a plant, often the bud. They are grown in test-tubes on a mixture of hormones, fungicides, sugars and agar (a type of jelly) in a laboratory. The cells multiply, forming shoots and roots. The most difficult part of the operation is to transfer the plant from the aseptic conditions of the test-tube to a normal growing medium. Provided this can be done, it is possible to develop several thousand new plants from one cutting within a year.

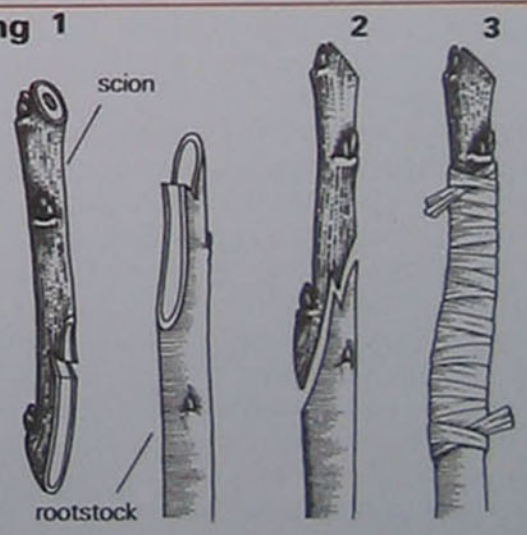
Above: Rows of year-old rowans (with compound leaves) and maples. Trees of this age and shape—one-or two-year olds with long slender stems and no side branches—are called whips. Along with feathered trees, which are similar but have side branches, they are often grown by Local Authority nurseries for landscaping and amenity purposes. They are also commonly grown by wholesale nurseries for sale to the public in garden centres and other outlets.



Right: Young cherry trees being secured to stakes for support. Instead of laboriously tying the two together, the nurseryman here is using a machine that fires plastic clips around the tree and stake, performing the operation in a fraction of the time. This allows him to stake great numbers of trees very fast. If a large nursery, containing perhaps many thousands of young trees, is to be economically viable, such labour-saving devices are essential.

Whip and tongue grafting

Of the many techniques of grafting available to the tree nurseryman, one of the most commonly used is whip and tongue grafting. The top of the rootstock is sliced off at an angle and the same angle of cut is made to the scion (**1**). (Notches are sometimes included in the cut to allow the two halves to interlock.) The scion and rootstock are then joined (**2**) and bound with tape (**3**).



PLANT PARASITIC NEMATODES

Some of our most damaging crop diseases are caused by tiny worm-like nematodes that lead a parasitic life feeding on, or even inside, plants.

Nematodes that live on or in plants are very much smaller than their animal-parasitic counterparts. Whereas the latter are big enough to be visible to the naked eye, some even being several centimetres or more long, very few of the plant-parasitic nematodes are longer than a millimetre or two. Thus they are, to all intents and purposes, invisible, and the diseases they cause have often been as puzzling to the scientist or farmer as those due to viruses or bacteria.

However, not all nematodes kill the plants they feed on. The more efficient parasites cause their host plant little damage. This is to their advantage since, while the host stays alive, it continues to provide the nematodes with food. But many other nematodes kill their host and, if a field of crops is being attacked, leave a tell-tale conspicuous bare patch, often circular in shape, in the middle of the crop.

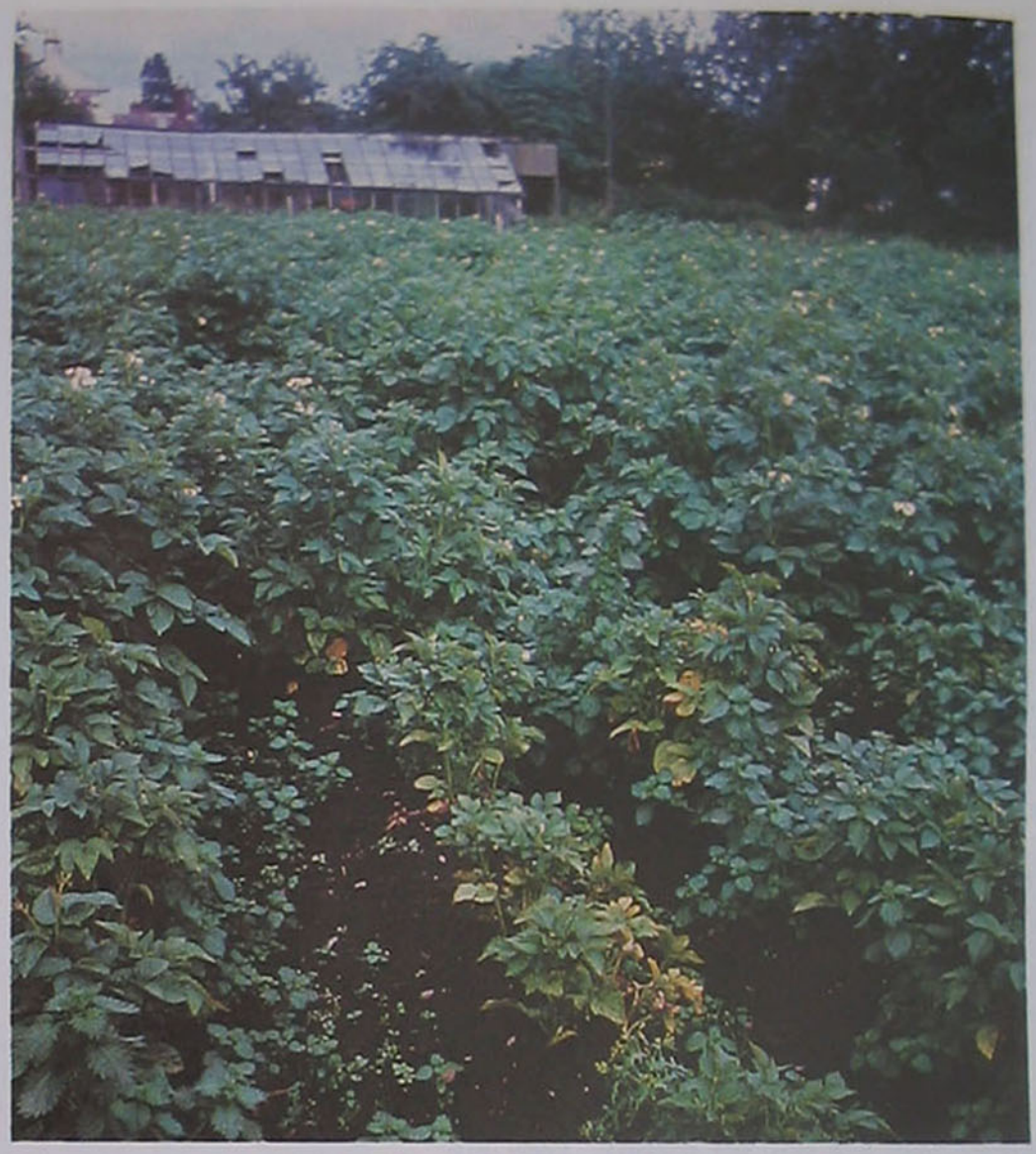
Hypodermic feeding Most plant nematodes have well-developed mouthparts with a syringe-like 'tooth', called an odontostyle, used for feeding. The nematode injects its odontostyle into a cell, squirts in some saliva and sucks out the partly digested cell contents. Nematodes attack all parts of a plant – the roots, stems, leaves, flowers and seeds – though the most numerous and widespread are the root parasites.

Nematodes can be divided into two types, depending on how they live. Some live outside the plant and feed on the surface cells; they are called ectoparasites. Others, the endoparasites, spend all or most of their life-cycle inside the plant tissue.

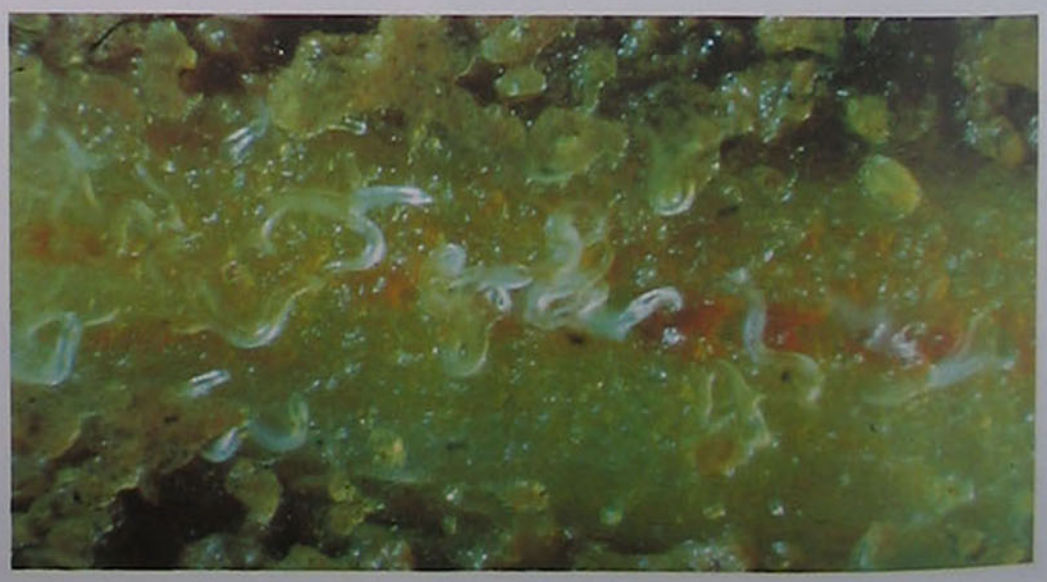
Burrowing invaders An excellent example of an endoparasite is the potato cyst nematode, a major scourge of gardeners who try to grow potatoes in the same soil year after year.

This species has an intriguing life-cycle. Juveniles invade potato roots and move through the cells as endoparasites, feeding continuously. The juvenile females then settle in one spot and produce secretions that cause the potato root to develop giant cells around their heads. The females feed on these cells, which are particularly well-supplied with sugars and other nutrients, hardly needing to move their heads as they do so. The females grow enormously, eventually expanding so much that, by the time they mature, they burst out of the root tissue.

The males, meanwhile, have matured and left the plant in search of a female that has just burst out of the root. Fertilisation takes place and the female dies. However, instead of decaying, her skin turns into a delicate leather-like bag – the cyst – that harbours the eggs. These cysts are just visible to the naked eye and look like pinhead-sized nodules on the surface of the root. The eggs can remain safe within the cyst for several years until a potato root passes by close enough to stimulate the cyst chemically into hatching. The



Above: Nematode damage often leaves a tell-tale dead patch in the middle of a crop (here, potatoes), but an examination of the dead plants rarely reveals their presence. Instead, the nematodes will have moved on to fresh pastures before their host dies.



Below: A mass of nematodes of the species *Trichodorus viruliferus*, each less than 1mm long, attacking a root of an apple tree. The ginger-coloured area is dead plant cells.

cycle then starts again.

Virus transmitters While most endoparasites stay inside the same host throughout their lives, nematodes that feed on the surface of a plant's roots – the ectoparasites – move through the soil feeding on one host after another. As they move on to new hosts, some of the larger ectoparasites transmit viral diseases, which can cause the leaves of a plant to become blotchy or mottled and the whole plant to become stunted and distorted, with poor cropping. Animals that spread viral diseases are called virus vectors.

Some of the most troublesome virus vectors among nematodes come from two genera, *Xiphinema* and *Longidorus*. They can grow to a length of 15mm ($\frac{3}{5}$in) and can be found in fleshy broken clods of earth, looking like tiny white wriggling rootlets. Though not possessing a protective resting stage, like the cyst species, these nematodes exhibit great endurance, some being able to survive in the soil for at least two years, presumably in a state of torpor. Even more amazing for creatures so small, they take two or three years to mature and can live to an age of five or even six years. Among the crops to suffer most from this group are raspberries, strawberries and hops.

How did they get here? Some 10,000 years ago, most if not all life over much of Britain was wiped out during the last Ice Age. It is easy to imagine how most animals managed to return here, and also how plants re-established themselves. But how did nematodes return?

Studies have shown that nematode populations rarely expand faster than about a metre a year, which is nowhere near fast enough for nematodes to have returned here between the end of the Ice Age and the severing of the British Isles from Continental Europe a few thousand years afterwards.

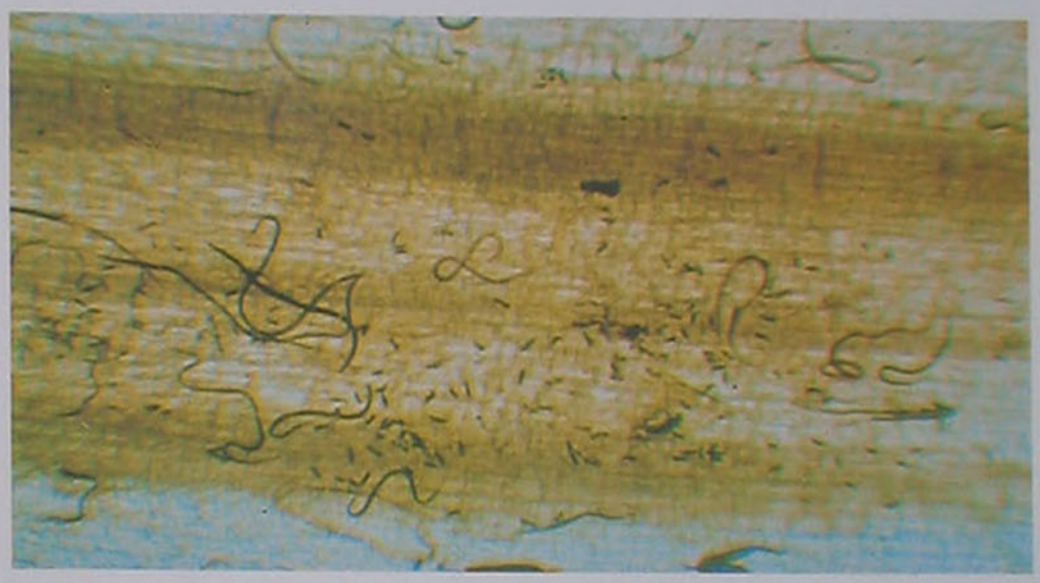
Obviously, nematodes must have taken some giant strides to get here, and quick ones too, because they would not have endured for more than a few days in dry soil. Perhaps they were helped by birds, whether long-haul migrants or species that inhabit woodland or muddy soils, particularly if they probe deep into such soils for their food. An ideal candidate is the woodcock. It lives in woodland throughout the year; it loves damp areas, walking around and probing the soil there for food – so it would pick up nematodes on its beak and feet – and it migrates, pausing on its way in suitable woodland to feed itself up for the next stage of its journey.

Once a woodcock had carried a few nematodes into Britain, other birds and animals would have spread them around the country, as would streams and brooks washing away the banks (and with them the nematodes) after a heavy fall of rain.

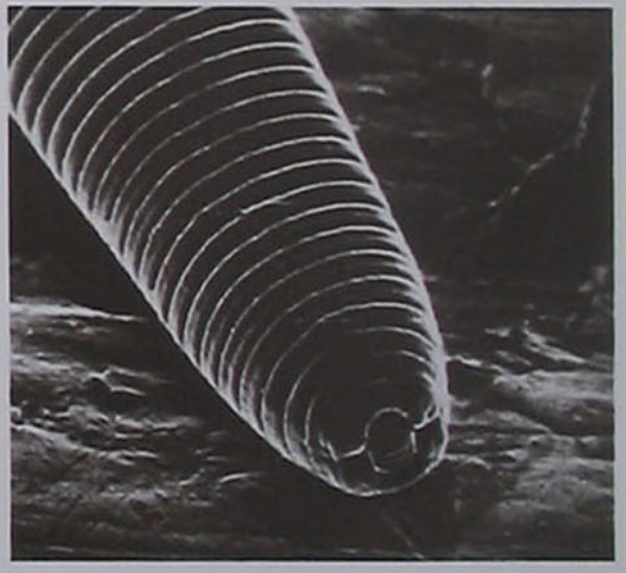
All that remained was for the expanding population of man to come along later and cut clearings in the woodland for agriculture, and the nematodes were there ready and waiting for him.

Feeding techniques

A characteristic feature of plant-parasitic nematodes is their hollow, sharply pointed 'tooth' – the odontostyle – that allows them to puncture cells and feed on the contents. Here a virus vector nematode, *Xiphinema diversicaudatum,* is shown piercing a root. The saliva this species pumps into cells to digest them contains viral particles that infect the plant.



Above: The part of a plant most vulnerable to attack by nematodes is the roots, though all other parts are liable to be infested by species specialised for the task. Shown here is a species of stem nematode, *Ditylenchus dipsaci,* photographed inside the stem of a broad bean.



Right: An electron microscope picture of a sheath nematode, *Hemicycliophora conida,* so-called because it has a double cuticle. This species is an ectoparasite on the roots of various plants, sometimes causing galls to appear.

Right: Cysts of the potato cyst nematode vary in colour from white, through pale yellow to tan-coloured. Chemical control of these pests is difficult since the cyst is impervious to many pesticides, but research into wild potatoes of the Andes has revealed genes for nematode resistance. These are now being bred into new varieties of potato.

CATTLE RARE AND STRIPED

In Britain there are three rare breeds of cattle distinguished by a pattern known as 'finching' or 'eelstriping': the Longhorn, previously a popular breed, and the Gloucester and Irish Moyled, both minority breeds restricted to a limited locality.

Above: An Old Gloucester bull. The manufacture of Double Gloucester cheese was associated with the Gloucester breed of cattle. Milk with small globules of fat is required for this cheese, and is still supplied by Gloucesters.

One of the most distinctive colour patterns found in cattle is the eelstripe. This ancient pattern was found in the aurochsen, the wild cattle from which today's domesticated breeds have descended.

The eelstripe, otherwise known as finching, is distinguished as a white or pale coloration that runs as a stripe down the middle of the back, over the hindquarters, and on the underparts and tail. The extent of the pattern varies considerably: in some animals the stripe starts at the withers, but in others it may not extend further forward than the mid-back. The colour contrast also varies: in some breeds the pattern is pure white on a dark background, while in others, including the aurochs, it is simply a light brown pattern on a darker base.

In the past, colour has been important in the formation and recognition of different breeds. Attractive colours and patterns were more likely to be selected, and the eelstripe pattern consequently was widespread. It is still found in widely separated localities, although only in limited numbers. The colour pattern is so strong that it has persisted for several generations, even when modern breeders have discriminated against it.

The Longhorn This was originally a triple-purpose breed. Because of its size and strength it was mainly a draught animal until only relatively recently, when horses superseded cattle as the main source of power on farms.

It also produced meat, and rich milk that was valuable in the manufacture of butter. The Longhorn was first developed in the Craven district of Yorkshire. From there it spread to Cumbria and Lancashire, and then to the Midlands, where it was transformed by the famous breeder, Robert Bakewell, into a specialist beef breed. For the past 150 years its main purpose has been the production of meat.

The body colour varies from light roan to a dark plum-brindle that is preferred by today's breeders. The nose and ears are dark, and a broad white stripe–the finching–runs the full length of the back and may extend to the top of the neck. The tail, rear parts, hind legs below the hock, the underparts and inside forelegs are white, and some animals have a white patch on each thigh.

The Gloucester In contrast to the Longhorn the Gloucester is found only in the region where it was developed. It owes its survival today to the enthusiastic support stimulated by local sentiment. It makes no claims to commercial qualities and breeders regard it more as a part of their local heritage. In the mid-1960s only two herds remained, and it was from the remnants of these herds that the breed was re-formed. Few herds now exist, although breeders keep one or two animals for conservation.

The breed, originally derived from the Glamorgan, was adopted in Gloucestershire by the Duke of Beaufort. It was claimed that the animals were docile enough not to be disturbed by the hounds of the Beaufort Hunt. The milk was used for Double Gloucester cheese and recently a herd has been established to recommence the production of this cheese.

The breed standards of the Gloucester favour a dark mahogany colour, but this can vary from black to mid-brown. The finching starts at the withers or mid-back, and the demarcation between the white and the body colour is more clearly defined in the Gloucester than in the Longhorn, with no suggestion of roan. The white continues down the tail and rump area and along the underparts. Some animals have a white 'garter' above the hocks on their hind legs.

Above: The Longhorn is distinguished primarily, as its name suggests, by its long, spectacular horns, which curve backwards from its convex forehead in a variety of unusual and eye-catching shapes.

Right: The Irish Moyled is now Britain's rarest breed of cattle. A few years ago it had dwindled to a relic population on only two farms, but recently several new herds have been formed.

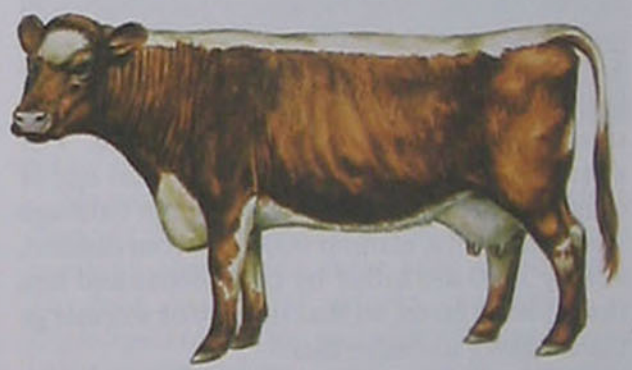
Below: An English Longhorn cow at Lowther Park in Cumbria. Longhorn herds are found in many parts of the country, especially in amenity centres and country parks.

The Irish Moyled This is now the rarest of British cattle breeds. It has never spread far beyond Ulster. Cattle from the two remaining herds have been used to form new herds in the last few years, both for genetic conservation and to preserve the local heritage. Like the Gloucester, it has little ability to compete effectively in the contemporary commercial cattle industry.

The Irish Moyled is a polled breed ('maoile' is the Gaelic word for hornless), but its colour pattern is almost identical to that of the Longhorn. The body colour is red or red-roan. The head is light coloured, with a dark muzzle and ears. The white pattern extends from the top of the neck or the withers along the ridge of the back, down the inside thighs and tail, and along the underparts.

The eelstripe or finching colour is linked in some way to the white colour with the dark points pattern found in the wild white cattle. In some cases crossing a wild white with a whole-coloured animal produces progeny with the finching pattern.

The Irish Moyled



THE PARASITIC WAY OF LIFE

Several thousand species of insects are parasitic in some way, many of them killing the victims on which they feed internally or externally.

The most efficient parasites are those that live at the expense of their hosts, but do not kill them. However, most parasitic insects–with the exception of fleas, lice and a few others–attack only other insects, and normally kill them. These 'parasitic' insects are perhaps best considered as carnivores–often internal carnivores–and the name 'parasitoid' has been coined for them. The vast majority belong to the insect orders Hymenoptera (the ichneumon and chalcid wasps in particular), and Diptera.

Controlling populations Parasitoids, of enormous importance in keeping down the numbers of insects, are in fact the major agents in the control of insect numbers after disease and variations in the climate. For example, calculations have shown that out of every 10,000 caterpillars of the large cabbage white butterfly, around 6000 die from disease, nearly 3500 are killed by parasitoids and less than 500 by birds, so that only 30 or so emerge successfully as butterflies.

Although caterpillars are a common choice for a host, parasitoids in fact attack a wide variety of insects, and very few species seem to be free from these troublesome predators. All the different stages of the life-cycle, from egg to adult, are vulnerable to attack by different parasitoids. Sometimes a single egg is laid in or on a host; sometimes several are inserted, often through a long ovipositor; and the methods of attack vary considerably.

Above: *Torymus cyanimus*, a chalcid wasp, laying an egg in the concealed larva of the gall fly *Urophora stylata*, which causes galls in thistle flowers. Its ovipositor is long and bristle-like in order to reach the intended victim.

Below: The parasitic fly *Conops quadrifasciatus* mimics bees and wasps, and specialises in attacking the red-tailed bumble bee.

The larvae may feed internally or externally, depending on the attacking species. The larvae of tachinid flies, for example, all live inside the body of the host, which is generally a caterpillar, although bugs, earwigs and woodlice are open to attack. Ichneumon and chalcid larvae include both internal and external feeders, the latter attacking mostly hidden prey such as tunnelling larvae. When the parasitoid larvae are young they feed on the body fluids and less important tissues so that the host/victim remains alive until the later stages of larval development, when all its tissues are attacked.

Spider victims Externally feeding ichneumon larvae often attack spiders. The parasitoid wasp *Zatypota percontaria* is an example; the small black female, measuring only 3-4mm long, manages to evade the dangerous chelicerae (fangs) of the chosen host (any of several families of spiders) to lay an egg on its body. The larva clings tightly to the spider's abdomen and absorbs the spider's body juices through a small hole made with its mouthparts. As the ichneumon larva grows, the spider is slowly killed, and then the larva spins an oval cocoon in which to pupate.

Some other species of parasitoid, such as the ichneumon *Gelis acarorum*, lay their eggs in spider egg cocoons and the larvae hatch out first and feed on the contents of the spider eggs.

Attacking aphids If you examine an aphid colony in the summer, you will probably see that some of the aphids have died and become hard and brown. These have been attacked by very common braconid wasps of the genera *Aphidius* or *Praon*. The small black females lay their eggs directly into the aphids bodies, one per aphid, where they quickly hatch and grow. When attacked, the aphid struggles and tries to fight off the braconid – sometimes successfully. Ants also help in the protection of 'their' aphid colonies.

After a few days, when the parasitic larva is full grown, the aphid dies and its skin hardens. The *Aphidius* larva then cuts a slit in the lower side and glues the aphid to the plant with a salivary secretion before pupating in a cocoon spun inside the hardened body. (*Praon* larvae make pupal tents actually beneath the aphid.) After a few more days, the adult emerges through a hole cut in the top.

However, the parasitoids themselves are not immune to attack. There are other small wasps, related to gall wasps, that lay their eggs within the parasitised aphids, and their larvae feed on the *Aphidius* larvae within. This very common phenomenon is called hyperparasitism.

Living under ladybirds Ladybirds are subject to attack by the common braconid *Dinocampus coccinelli*. The female braconid lays an egg inside the adult ladybird, attacking from below and inserting her ovipositor between the body plates. The host in this case does not die, and can live a normal life after the braconid has emerged – provided it can break away from the pupal tent that has been made beneath it.

Wasps and flies Chalcid wasps of several families form a vast group of small or very small parasitoids, mostly 1-3mm long and often with brilliant greenish metallic coloration. They attack all stages of the host, although eggs and larvae are preferred, and many of them are hyperparasites.

Above: This tiny wasp, *Trichogramma evanescens*, attacks the eggs of no less than 150 different insects. Here it is laying its own eggs inside alderfly eggs.

Right: An aphid attacked by the parasitoid *Praon* becomes mummified when the larva developing within is full-grown. The larva then emerges and spins a pupal tent beneath the aphid's body.

Below: An example of hyperparasitism. This small wasp, a species of *Alloxysta*, is laying its eggs within an already parasitised aphid. The female wasps can recognise the parasitised aphids and ride around on their victims' backs, probing with their ovipositors for the *Aphidius* larva already present within.

Members of the genus *Torymus* are green chalcids that attack the larvae of gall wasps, reaching them with their long ovipositors. *Torymus bedeguaris* attacks the larvae of *Diplolepsis rosae* (the gall wasp that makes the robin's pincushion gall), while *Torymus cyanimus*, a very similar species, attacks the larvae of the fly that causes galls in thistles.

Trichogramma species are a group of tiny chalcids that attack insects' eggs. Before laying, the female walks over the selected egg, leaving a scent trail which informs other females that the egg is already parasitised.

Bee mimics Another interesting family of parasitoid flies are the Conopidae, or thick-headed flies. They often mimic bees and wasps both in coloration and in the movements around flowers and bushes.

Conopidae specialise in attacking the insects that they mimic. They seize the foraging insects in a quick strike, sometimes falling to the ground with them in a violent struggle. The fly lays a single egg inside the abdomen of the bumble bee or wasp and the larva grows inside while the host continues working for a while. When the host's abdomen is emptied, the larva reaches into the thorax and the host quickly dies.

Pupation takes place within the dead shell of the host and the winter is passed in this stage, the adult fly emerging the following year.

WATERFALL WILDLIFE

Although Britain has no giant waterfalls, it is graced by thousands of small ones, their attractions reflected in such names as High Force, Cauldron Snout and Grey Mare's Tail.

Most people, when they think of waterfalls in Britain, consider only those in the Highlands of Scotland, the Lake District and the Snowdonian mountains. However, many smaller, equally spectacular, falls are found in the river valleys of Devon, the mountains of South Wales and in the Pennines.

Waterfall formation Most of our waterfalls have been formed by one of three main processes. First, weaknesses in parent bedrock in the uplands, developed during volcanic and other earth movements, have resulted in upwellings and slippage along fault lines. Where this has happened in river valleys, waterfalls frequently occur. Such falls often have sheer rock faces with turbulent,

Below: The waterfall at Inversnaid, Loch Lomond. The constant humidity created by the falling water gives life to a host of mosses and liverworts in the fall itself, and encourages flowering plants among the surrounding rocks. Waterfalls not only have immense beauty; they can also mirror contrasting moods. The rippling, sun-flecked white water on a summer's day can suddenly change to an all-embracing and terrifying spate of tumbling brown water.

swirling pools at their bases.

Secondly, when the glaciers gouged out their wide U-shaped valleys they left hanging, almost in suspension, feeder streams from the highland glens and gullies. Such streams now often cascade down the steep valley sides, leaping over rock faces and boulder-strewn slopes. Thirdly, some waterfalls, most notably those underground, have resulted from water actually dissolving rock.

Contrasting habitat A waterfall is a habitat of great contrasts. At any moment a gentle trickle can turn into a torrent of tremendous physical force which has the power to remove almost anything in its path. On the other hand, within most waterfalls there are cracks and overhangs cushioned from rapid environmental change. Crevices within waterfalls may be totally enclosed, with niches that receive light and constant humidity, but are protected from any sudden diurnal and seasonal temperature fluctuations by the water passing overhead.

The other major feature of waterfalls, influencing all the plants and animals in their vicinity, is the constantly high humidity they create. In wide valleys, only the crevices and gullies immediately adjacent to the falls are always bathed in a fine spray of water, but in narrow, steep-sided valleys the picture is very different. The moisture content ranges from dripping surfaces near the falls, through the moisture-laden atmosphere of adjacent woodland, to a damp pervasive mist many hundreds of feet above and downstream of the falls themselves.

Above: The dipper is a specialised bird of rapids and waterfalls. It even swallows stones to increase its body weight so that it can walk and feed underwater in torrent conditions. Birds such as the dipper, the grey wagtail, pied wagtail, goosander, wren and ring ouzel may nest within crevices adjacent to waterfalls.

Right: The greater wood rush is one species able to colonize the banks of falls in low-lying areas.

Below: Pink purslane may well be found growing beside waterfalls, flourishing in the wet conditions. It can be recognised by its pale pink flowers. One of the more unexpected finds in tiny crevices is the sight of many natural 'bonsai' trees. Miniature sycamore, ash, willow and alder trees can often be seen, their constricted root systems providing enough anchorage to resist floods and support minute gnarled branches.

The rock faces, which endure tremendous erosive flood forces and have been polished to a smooth surface by such forces, have rich plant communities. No flowering plants can withstand the harsh environment, but some algae, liverworts and mosses thrive.

Two types of algae On waterfalls both felt-forming and filamentous blue-green algae can be found. Genera such as *Chamaesiphon* and *Homoeothrix* form very flat crusts on the surface of rock, the former producing minute spores at the crust/water interface, while the latter have hair-like filaments pointing away from the rocks. Slimy pelts of brown and various hues of green are frequent on the lips of falls. These are produced by *Phormidium*, which is composed of tightly interwoven filaments pressed close to the rock surface to reduce the chance of being washed away during floods.

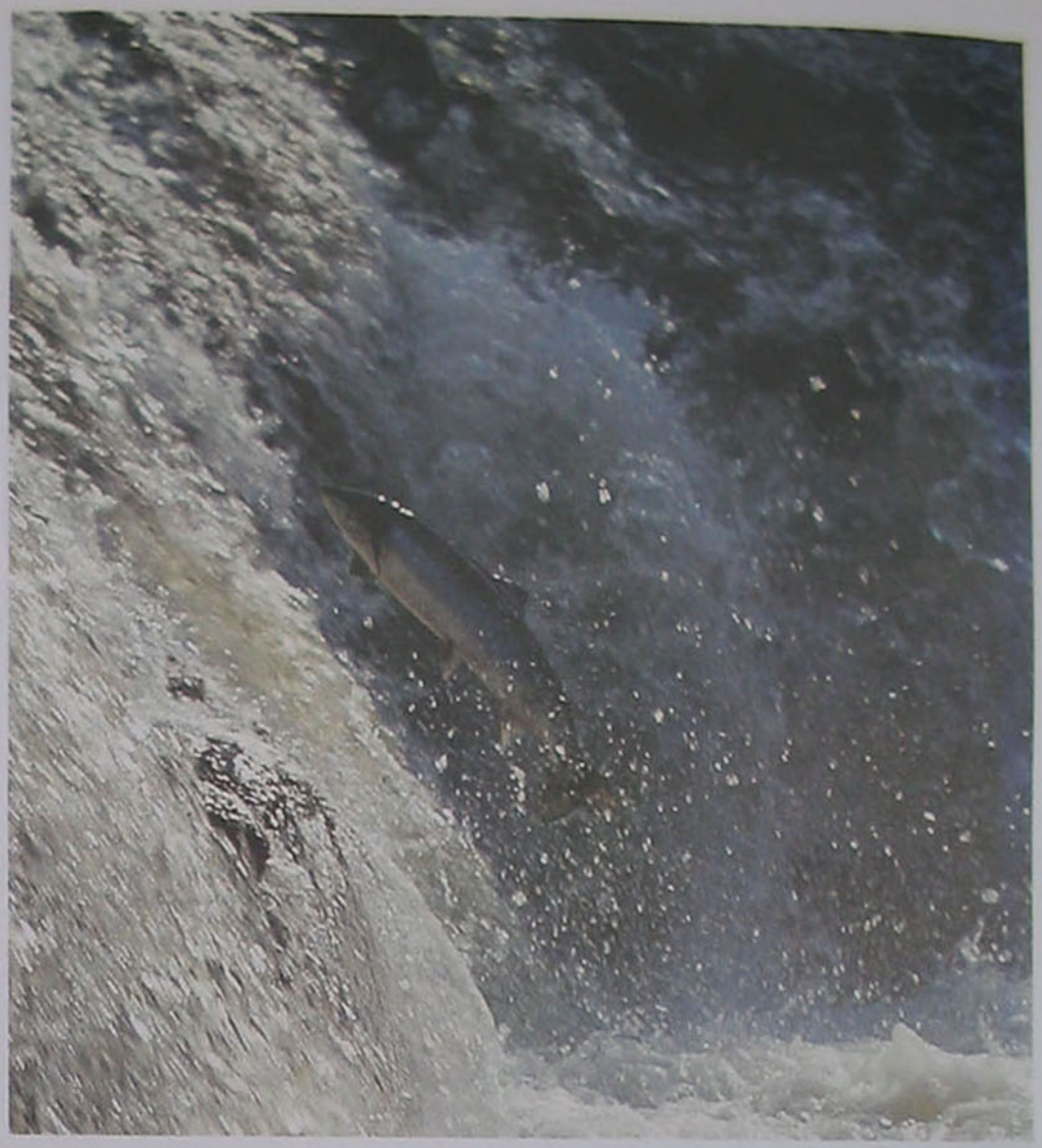
There are also the tough, leathery filamentous tufts of *Tolypothrix*; this blue-green alga, like many of its relatives, is an important component of many nutrient-poor upland communities because it has the ability to 'fix' atmospheric nitrogen.

Simple blue-greens are not the only algae to occur on waterfalls. *Lemanea*, a filamentous red alga, is common on waterfalls in spring, but during the summer months is replaced by

a variety of filamentous green algae.

Liverworts and mosses Whereas much of the algal growth on waterfalls is somewhat transient, the cushions and colonies of the liverworts and mosses are much more permanent. In the uplands, liverworts dominate, only a few mosses being found. Many small falls are smothered in cushions of *Nardia*, *Marsupella*, *Scapania* and *Solenostoma* species, all tightly pressed to rock surfaces to avoid being dislodged during spates. Occasionally the less common *Plectocolea*, *Cephalozia* and *Hygrobiella* also occur, but these are more common in the broken waters of rapids. In the large rivers in the highlands the only common moss is *Blindia acuta*, a small plant with very tough, pointed leaves which resist the pulling force of torrent flows. *Schistidium agassizii* is another moss of upland waterfalls, but until recently had never been recorded in Britain. A classic species of Scandinavian snow-melt rivers, it has now been found in rapids and waterfalls of rivers in many parts of North Wales, the Lake District, the Pennines and also in Scotland.

Where waterfalls occur downstream on rivers, the typical liverwort-dominated community of the uplands is replaced by a moss-dominated one. Instead of tight, rounded cushions, the mosses form less compact growths which are attached to the rock by holdfasts. Many of the shoots are densely branched with aerodynamically curved tips which serve to deflect water. Typical species are *Scorpidium scorpioides*, *Hygrohypnum* species, *Fontinalis squamosa* and *Rhynchostegium riparioides*. On waterfalls which have base-rich water flowing over them, *Amblystegium fluviatile* and *A. tenax* often replace the other mosses.



Above: The leap of the salmon as it struggles to overcome a waterfall is an extraordinary feat of skill, power and endurance. In general, few animals are particularly associated with waterfalls. For some, such as the migratory salmonids, they may even form a barrier, above which point in a river system they cannot penetrate. Where falls are passable, salmon frequently make use of the tremendous energy they can produce by jumping powerfully from upcurrents in the swirling pools below. Young eels also migrate upstream, but they are assisted by their remarkable ability to wriggle up vertical rock faces.

Left: The bank sides and rock fissures near waterfalls provide an ideal niche for the bright yellow marsh marigold which bursts into flower in the spring.

Plants of the splash zone Adjacent to waterfalls are dripping rock surfaces and crevices that are frequently smothered in vegetation. Again, it is the mosses that dominate, but some lichens, ferns and flowering plants are also conspicuous.

In upland waterfalls between the dry flow level and the flood level, the dark, tough, leathery lichen *Dermatocarpa fluviatilis* is very common, and occasionally the much rarer and lighter *D. leptophyllum* may also be found. Where the rock is base-poor, *Racomitrium aciculare* may be very common, growing among the lichen colonies. Where the rock is more base-rich, *Schistidium alpicola* and *Cinclidotus fontinaloides* replace *Racomitrium*. Frequently, too, many of the same species that occur in the permanently inundated parts of the fall also occur in the zone that alternates between being desiccated and being abraded by flood water. Such plants often show clear signs of living in this harsh environment, being tough and black.

Plants within the more protected environment of crevices and cracks in the splash zone are very different. They are usually a luxuriant

green in colour, and frequently there is so much competition for the prime sites that one plant species grows on top of another. It is a common sight to see cushions of *Dichodontium*, *Dicranella*, *Rhizomnium* and other mosses with other plants rooted into them. The hard fern is one example of a common fern found in such a habitat, and the brittle fern is a rare plant which requires just such a moisture-laden habitat. In the highlands the easily confused bog pimpernel and the alpine willowherb may be seen straggling over moss cushions. Both have delicate pink flowers, but the latter's elongated fruits easily distinguish it in late summer. Procumbent forms of the starwort *Callitriche stagnalis* are also commonly seen growing as part of the splash zone community.

On more low-lying waterfalls, adjacent rock fissures invariably have rich higher plant communities. Unshaded spots may burst into bloom with the bright yellow spring flowers of marsh marigold and globe flower, followed later by the delicate blue of water forget-me-not, pink purslane, white scurvy grass and the multi-colours of monkey flower. Among these tiny wild gardens can also be found rushes, sedges and grasses.

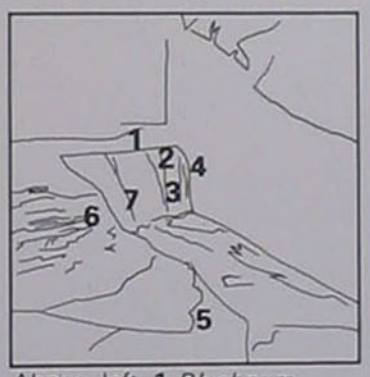
Waterfall insects Few insects are specialised for living in waterfalls, although some are ideally suited to take advantage of the lack of competition from others. Most are there because they need to be constantly bathed in oxygen-rich water. Most frequently, insects take advantage of the shelter offered by the leeward edge of any submerged obstructions. In the most rapid falls it is unlikely that any insects other than those which are permanently attached to rock surfaces will be encountered. The commonest examples are minute case-living caddis larvae and the larvae of blood-sucking blackflies, both of which may gather on exposed rocks.

In cascading falls where the rock faces are not always sheer, it is possible to find mobile insect larvae which are specially streamlined or flattened to avoid being washed away. The best examples are some mayflies and stoneflies, with species of *Ecdyonurus*, *Rhithrogena* and *Perlodes* often present. Some mayflies have even developed hooks to cling to rough rocks. More varied populations occur within the protection of the liverwort and moss communities and in the shelter offered by minute nooks and crannies.

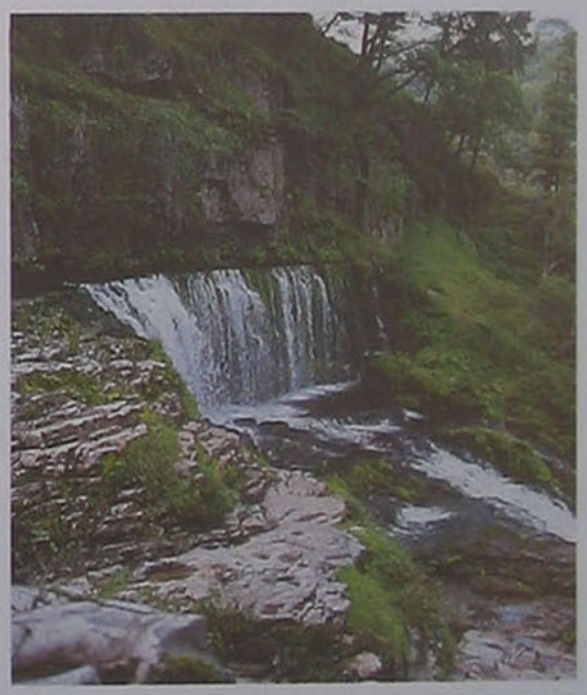
Above: A stonefly on a mossy stone; the aquatic larvae of this insect find refuge in the shelter of mossy nooks and crannies and take advantage of the extremely oxygen-rich water of waterfalls.

Right: Another species to find a refuge among the moss of waterfalls is the alpine willowherb, a plant which grows in mountain districts and bears elongated fruits in late summer.

Waterfall plant-life

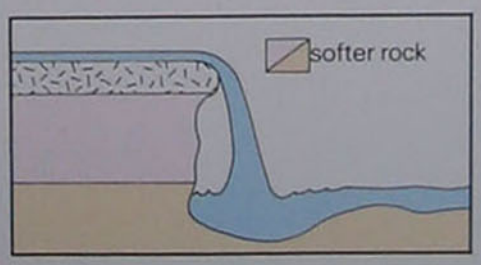


Above, left: **1** *Blechnum spicant* fern; **2** liverworts *Scapania undulata, Solenostoma triste;* **3** mosses *Rhynchostegium riparioides, Amblystegium fluviatile*; **4** liverwort *Pellia epiphylla;* **5** common sedge, globe flower, water forget-me-not; **6** moss *Dicranella palustris;* **7** filamentous algae.

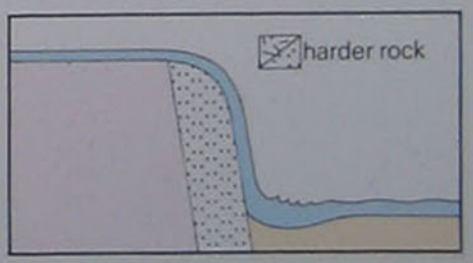


Two types of waterfall

1 Where the rock beds are horizontal, soft rock underlying a layer of harder rock is cut back by the water and a deep pool erodes at the base of the fall. The soft rock behind the fall may form ledges suitable for plants. **2** In a vertical or steeply inclined stratum, hard rock prevents the progress of upstream erosion. The soft rock at the base of the fall erodes slowly, producing a shallower pool. There are few ledges for plant life.



Above: Animal life in the turbulent pool is almost minimal.

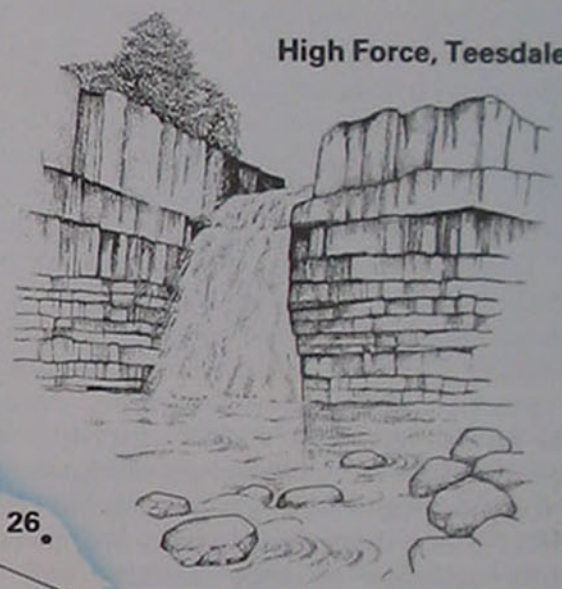


Above: The calmer, shallower pool may harbour water insect larvae.

Waterfalls of Britain and Ireland

1 Eas-Coul-Aulin, Unapool; **2** Falls of Measach, Corrieshallock Gorge, Ullapool; **3** Fall of Foyers, Loch Ness; **4** Dog Falls, Glenaffric; **5** Allt Coire nam Bruardaran, Isle of Skye; **6** Braan Falls, Tayside; **7** Inversnaid Falls, Loch Lomond; **8** Alva Falls, Alva; **9** Bonnington Linn, Lanark; **10** Corra Linn, Lanark; **11** Grey Mare's Tail, Moffat; **12** Skelwith Force, Ambleside; **13** Lodore Falls, Derwentwater; **14** Aira Force, Ullswater; **15** Dungeon Ghyll Force, Grasmere; **16** Scale Force, Buttermere; **17** Low Force, Teesdale; **18** High Force, Teesdale; **19** Cauldron Snout, Teesdale; **20** Catrake Force, Keld; **21** Kisdon Force, Keld; **22** Thornton Force, Ingleton; **23** Pecca Falls, Ingleton; **24** Hardraw Force, Wensleydale; **25** Aysgarth Falls, Wensleydale; **26** Mallyan Spout, Goathland; **27** Kinder Down Falls, Hayfield; **28** Swallow Falls, Capel Curig; **29** Aber Falls, Llanfairfechan; **30** Conway Falls, Betws-y-Coed; **31** Pystyll y Rhaeadr, Clwyd; **32** Mawdach Fall, Dolgellau; **33** Dolgoch Fall, Tywyn; **34** Rheidol Falls, Devil's Bridge, Dyfed; **35** Sgwd Ddwli, Powys; **36** Scwd yr Eira, Glyn Neath; **37** Becky Falls, Bovey Travey; **38** Lyd Falls, Dartmoor; **39** Rocky Valley Falls, Tintagel; **40** Glencar Falls, Glencar, Co Leitrim; **41** Powerscourt Falls, Dublin; **42** Torc Falls, Killarney, Kerry.

Fall of Foyers, Loch Ness



High Force, Teesdale

Pystyll y Rhaeadr, Clwyd

EPPING: A FOREST FULL OF FUNGI

Many species of larger fungi are restricted to woodland and a small, but important, number are confined to ancient deciduous woods such as Epping Forest. Here, in ideal conditions, a fascinating and colourful array of fungi can be found.

Above Shaggy pholiota (*Pholiota squarrosa*), one of the parasitic fungi, forms dense clusters at the base of tree trunks and stumps in the autumn. Usually found on deciduous trees, it will occasionally attack conifers as well.

Epping Forest in Essex is one of a small number of important ancient woodlands and parklands in England and Wales which has not been extensively clear-felled and replanted since the Middle Ages. Such relatively undisturbed woodland is a refuge for many rare plants and animals that take advantage of the special conditions existing as a result of a long-established and unbroken period of tree cover.

Ideal conditions Nearly 600 species of larger fungi have been recorded from Epping Forest, the records dating back to 1726. This total represents about 20% of all the species of large fungi recorded from the British Isles.

There are several important reasons why the Forest supports such a rich and diverse population of fungi. A wide range of different trees grow there, many of which are species that form a special association, known as mycorrhiza, with a large number of woodland fungi. The trees vary widely in age, ranging from saplings to long-established and often partially decrepit veterans up to 300 years old – ideal specimens for fungal growth. The glades and more extensive grassy areas of the Forest support many species of grassland fungi as well, which are not normally found within uniform woodland.

Also, Epping Forest is not subject to tree-felling, drainage, formation replanting, or use of inorganic fertilisers – all aspects of modern woodland management that adversely

affect the growth of fungi. These factors combine to produce a range of special fungal habitats within the Forest, including rotting wood and decaying tree stumps, areas of sawdust and wood chippings, dung from cattle and horses, small boggy areas, and burnt patches from picnic fires and forest maintenance.

When and where to look Many of the commoner fungi can be found in most years in the Forest. The best conditions for growth are when a warm and not too dry spring is followed by a warm, wet autumn.

In woodland, fungi grow in a wide variety of places, governed by the methods by which they obtain their nutrition. Some species are confined to leaf litter, humus and decaying wood. Others have a special symbiotic relationship with trees, with which they grow in conjunction, while a third group are parasitic on the trees.

Above: Look out for the striking orange peel fungus (*Aleuria aurantia*) beside paths and in grassy areas of the Forest. If a specimen is kept overnight in a small, airtight box, the fruiting area of the orange disc will produce so many spores that when the box lid is removed, the fungus will appear momentarily to be smoking.

Left: The unusual colours of the amethyst deceiver (*Laccaria amethystea*) can be seen in many types of woodland from late summer to early winter.

Below: The spores of the bird's nest fungi (*Cyathus olla*) develop in small packets known as peridioles. When ripe, they lie in a small cup, looking like birds' eggs in a nest, hence the fungus's common name.

Woodland floor dwellers Most of the larger fungi are found among the leaf litter. This group includes puff-balls, earth-stars, earth-balls, stinkhorns and bird's-nest fungi – all members of the group known as Gasteromycetes. This name alludes to the fact that the spores in this group develop within the cavity of the fruit body and are only released at maturity.

Epping Forest contains a wealth of Gasteromycetes, some of which are quite spectacular in appearance. The stinkhorn (*Phallus impudicus*) is one of the most noticeable; in this species the spores develop in an underground structure resembling a snake's egg in texture. At maturity, the egg bursts and the spores – combined in a dark, mucilaginous mass on a small cap – are elevated on a brittle, pitted stalk about 15cm (6in) in length. The whole plant emits a strong stench reminiscent of bad drains or carrion. This odour attracts flies which walk over the cap and carry away the sticky spores.

The common earth-ball (*Scleroderma citrinum*) is a poisonous species found on earth banks. It has a thick, leathery exterior covering a purple-black spore mass when ripe. This distinguishes it from the puff-balls (*Lycoperdon* species) which can be recognised by their thin, papery skin. The impact of raindrops on the skin surface causes spores to be released via a pore at the top when the puff-ball is mature. *Lycoperdon pyriforme*, the only British species found growing on wood, is common on sawdust in the Forest.

Two species with an unusual appearance are the earth-star and the bird's-nest fungus. The earth-star is common in the Forest among beech leaves and resembles a puff-ball with a star-shaped surround. The bird's-nest fungus, a rarity in the Forest, has little cups containing small packets of spores which are scattered by raindrops.

Although most of the larger fungi appear in the latter half of the year, generally disappearing after the first winter frosts, a few are found only in spring. The edible common morel is sometimes frequent in Epping Forest on burnt ground in late April and May. It is easily recognised by its brown, honeycomb-

like cap. Equally distinctive is the orange peel fungus, which often occurs beside paths; its common name describes its appearance exactly. Both these species belong to a large group of fungi called the Ascomycetes.

Mycorrhizas Many fungi are involved in a mutually beneficial relationship with a particular tree species, an association which is called a mycorrhiza. Beech, birch, hornbeam, oak and willow–all common species in the Forest–act as host to some of the more conspicuous woodland fungi. When mycorrhizas are formed, the underground fungal threads (mycelium) of the fungus envelop the root tips of the tree and, in return for carbohydrates secreted by the tree, the fungus assists its host in the uptake of nutrients from the soil. It seems that this relationship is essential for the successful formation of fruits in the fungus, and is also important for the healthy growth of the tree. Mycorrhizas tend to develop more abundantly where there is a deficiency of nutrients in the soil, thus they are not associated with ash, elm and sycamore, which grow on richer soils.

The most important genera which form mycorrhizal associations almost exclusively, and are therefore confined to woodland and parkland, are *Amanita*, *Cortinarius*, *Boletus*, *Hydnum*, *Lactarius* and *Leccinum*. Some species, such as the red and white spotted fly agaric (*Amanita muscaria*) and the orange birch bolete (*Leccinum versipelle*), are nearly always associated with a single species of tree –in this case, birch. Other species, such as the blusher and the amethyst deceiver, grow in association with several species of tree.

Above: Earth-stars (*Geastrum triplex*) are often found among the autumn leaves in Epping Forest. The centre of the fungus resembles a puff-ball, surrounded by four to five arms which form a star.

Right: The colourful beechwood sickener (*Russula mairei*) is inedible, causing sickness if eaten.

There are 31 species of the often colourful *Russula* reported from the Forest. One beautiful example is the beechwood sickener which, as its name infers, occurs most frequently under beech. Like the closely related sickener (*Russula emetica*) which occurs under conifers, the beechwood sickener has a rose-red cap and a brittle white stalk.

Parasites The presence in the Forest of many over-mature trees means that several species of parasitic fungi–some eventually responsible for the death of their host–are found. The heart-wood of many beech trees in Epping Forest is chronically affected by the large, corky brackets of *Ganoderma adspersum*. These form at the base of old and recently fallen trees and often produce so many coffee-coloured spores that the surrounding vegetation is completely coated. Similarly, most old birch trees will eventually be killed by the birch polypore (*Piptoporus betulinus*) which forms separate white or brown brackets. A variety of other species, such as the shaggy pholiota, the sulphur tuft and the oyster mushroom, are less aggressive parasites on trees in poor condition.

Fungi of the Forest

BRILLIANT BRITISH WRASSES

Our most colourful group of fishes, the wrasses, stay mainly at sea, but you may be lucky enough to catch a glimpse of one in a rock pool.

Above: The characteristic bright blue head and flanks, contrasting with the orange belly, of a male cuckoo wrasse make this the most colourful wrasse.

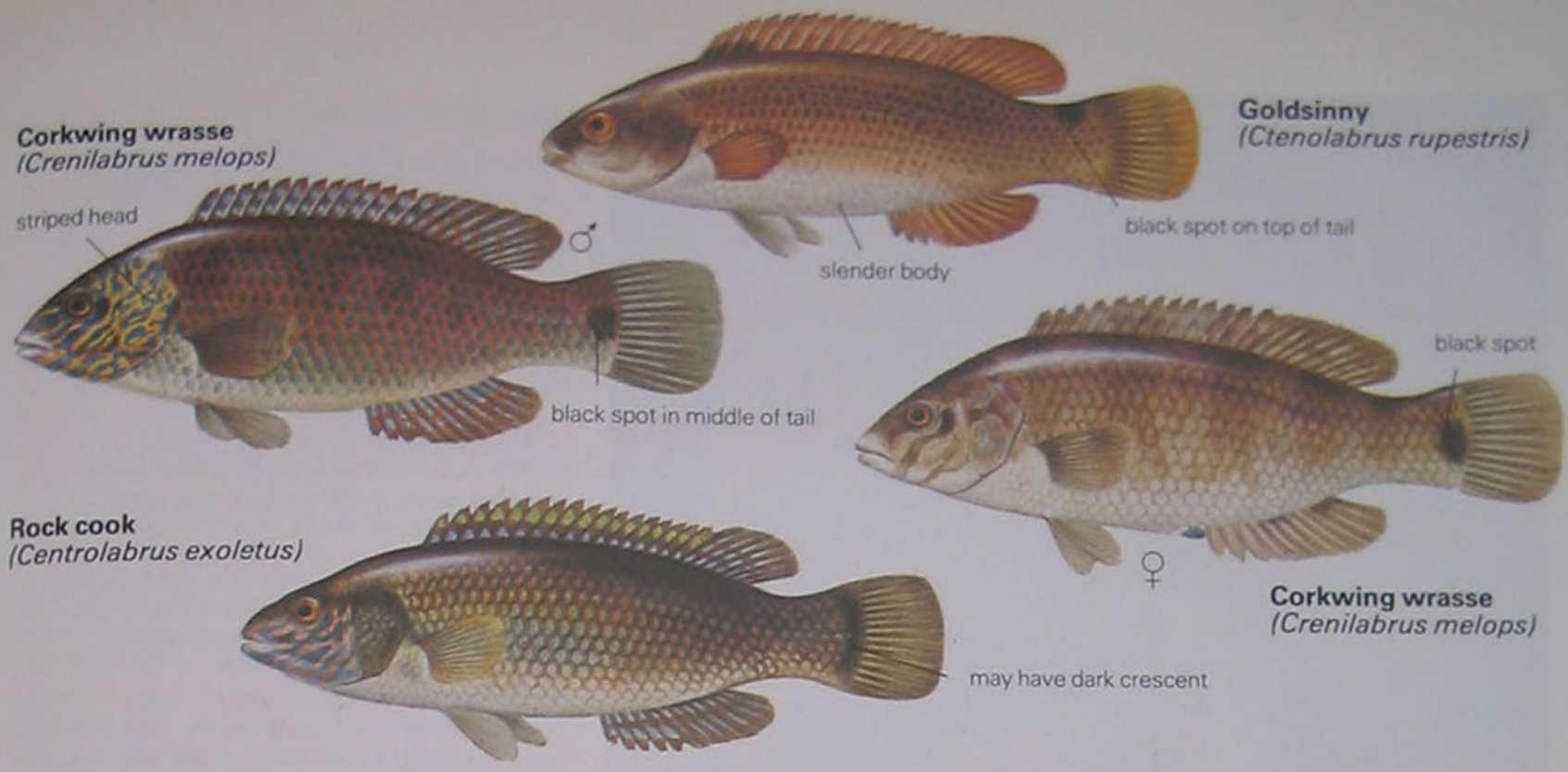
Below: Rock cooks are usually reddish-brown or brown, fading through green or yellow flanks to a pale belly, but the males can be a bright violet-blue, especially during the breeding season. The colour comes from tinges in the centre of each scale.

As well as the ballan wrasse, which is the largest of the British wrasses, there are four other species often seen by divers, sea-anglers and rock pool enthusiasts. Just as the ballan wrasse has the strange ability to change sex from female to male during its life, so one of the other wrasses goes a stage further. The cuckoo wrasse not only changes sex, it also undergoes a startling colour change from the red of the female to the brilliant blue of the male.

It is not yet certain whether the other three common British wrasses–the corkwing, the goldsinny and the rock cook–change sex in the same way, though it seems likely that they do. Apart from the rock cook, all these wrasses are found around the coast of Britain, except off the East Anglian bulge.

Colourful cuckoos The cuckoo wrasse is the most colourful and entertaining of all the British wrasses. The brilliant blue of the male, with its dark head, blue flanks and orange belly, contrasts so sharply with the beautiful red of the female that the two were originally described as separate species.

In summer, cuckoo wrasses are often found close inshore in rocky areas, where they are frequently caught by anglers. It is to be hoped that they are returned to the sea once their colouring has been admired, for they do not make good eating. Divers are also likely to be familiar with cuckoo wrasses, since these



fishes have an insatiable curiosity and often follow a diver round, snapping up any small crustaceans or molluscs that are unearthed.

As with the ballan, cuckoo wrasses are born female and then change sex between the ages of seven and thirteen. They live for a total of about 20 years, whereas the other, smaller British wrasses usually have a life-span of only half this figure.

They grow to a length of 35cm (14in) and may weigh as much as 1kg (2lb 3oz). By comparison, the ballan can exceptionally grow to be 60cm (2ft) long and weigh 3½kg (8lb).

Cuckoo wrasses are territorial and spawn in pairs. Their courtship is fascinating to watch: after excavating a hollow nest in the sea-bed, the male attracts a female by performing a display in which his head blanches a pure white in a matter of seconds. The colour re-appears just as quickly.

Slender goldsinny This wrasse is more commonly seen by divers than by anglers or rock pool hunters, though it is occasionally found in pools at extreme low tide.

The body is slender and golden, with a characteristic black spot on top of the tail, just in front of the fin. Its favourite habitat is a rocky environment, preferably with a jumble of boulders with small crevices and caves that provide some refuge.

The goldsinny has just as great a sense of curiosity as the cuckoo wrasse, possibly even greater. A diver finding this fish among some boulders has only to keep quiet and breathe gently, and he can entice it out by the glint of a camera, a knife or a touch. In some areas the goldsinny is so used to divers that it can be fed by hand and will even come up to a camera lens and nibble at it.

The goldsinny eats almost anything that is easily captured, especially amphipods, small molluscs and worms. It has strong forward-pointing teeth that enable it to tear off encrusting bryozoans from rocks and seaweeds.

Above: Among our more common wrasses only these three species are likely to be found in a rock pool, the cuckoo and the ballan wrasses being too large to be trapped that way. All three are small, about 12-23cm (5-9in) long, and are best distinguished by their tail markings. Only in the corkwing do the sexes appear different.

Below: Even though its eyes are open, this corkwing wrasse is asleep at night on a frond of kelp.

Hardly anything is known about its courtship and mating habits. Occasionally it grows to a length of 18cm (7in) but a more typical size is about 12cm (5in).

Common corkwing The commonest of the three smaller wrasses, the corkwing wrasse is frequently found in seaweed-filled rock pools as well as below the tide level to a depth of about 30m (15 fathoms). Another favourite habitat of this fish is eel grass beds. Unlike the cuckoo and the goldsinny, the corkwing keeps very much to itself and rarely approaches a diver or takes any interest in his activities.

The colour of a corkwing wrasse is variable, usually green or greenish-brown; the sexes are similar except that the male has blue and green lines on its head. Like the goldsinny,

Satellite males

Many animals have what are known as 'satellite males': sub-dominant, though sexually mature, males that seek to exploit mating opportunities belonging to dominant males.

In most cases this amounts to males that do not yet have their own territory taking any opportunity to fertilise the eggs of females belonging to the dominant males – a satellite is usually temporary and eventually sets up his own territory.

In the corkwing wrasse, however, there exists a small number of *permanent* satellites. These males have the colouring of females and mature much earlier than normal males. Moreover, they have much larger testes, which cause their bellies to bulge so that they look exactly like pregnant females.

These satellites fool the males into courting them as females; they then rush into the male's nest and fertilise any as yet unfertilised eggs. If a normal male tried to do this, he would be chased away by the resident male. For the satellite, it is a chance to mate without the effort of maintaining a territory and defending it against other males.

the corkwing has a tail-spot, but this time it is in the middle of the tail before the fin, not on the top. A corkwing may exceptionally reach a length of 25cm (10in), but is usually only about 15cm (6in) long.

The courtship of this small wrasse has been well studied. In early summer the male builds a nest of seaweed on the sea-bed and courts the female, whom he recognises by her colour and her distended, egg-filled abdomen. He entices her into the nest with an elaborate dance, after which she lays her eggs and the male fertilises them. He may entice several females into his nest in this way. Afterwards, the male guards the eggs and oxygenates them by fanning them with his tail, a form of behaviour also performed by the stickleback. When the young hatch, they drift freely in the plankton for a while before coming inshore by the autumn.

The corkwing wrasse feeds mainly on small crustaceans and molluscs.

Rare rock cook The rock cook, sometimes called the small-mouthed wrasse, is perhaps the least well-known of the five species. It is distributed only locally along our coasts and does not seem to occur along the east coast of England, nor along the English Channel east of Dorset.

Males and females are difficult to tell apart, in both sexes the general body colour being reddish-brown, grading into greenish-yellow on the flanks and white on the belly. Each scale has a blue-green tinge in the middle. This may be accentuated in the males, especially during the breeding season, so that they become a beautiful bright violet-blue. The rock cook does not have a tail spot, which makes it easy to distinguish from the other wrasses, though it often has a dark crescent across its tail fin. It usually grows to about 12cm (5in) long.

This species rarely inhabits rock pools; instead it prefers seaweed-covered rocks in shallow waters (to a depth of 25m/14 fathoms), or beds of eel grass.

As yet, little is known about the rock cook's feeding or breeding habits, but it is the only British species of wrasse that has been observed in the wild to 'clean' other fishes of their parasites. Both the corkwing and the goldsinny have been seen to do this in aquaria, but not yet in the wild. It is, however, a common behavioural habit among tropical wrasses.

Above: The blue-striped head of the male corkwing wrasse serves to distinguish it from the stripeless green-brown head of the female. This is the commonest of the smaller wrasses, though it may not be seen so often since it lacks the curiosity of the cuckoo wrasse or the goldsinny.

Below: The golden body of the aptly named goldsinny is marked with a black spot on top of its tail, just in front of its tail fin.

WATER RAILS: HEARD BUT RARELY SEEN

Detailed studies by ornithologists have shown that the water rail, one of our most secretive water birds, is far commoner in Britain and Ireland than was first suspected. Despite its cautious nature, the water rail often advertises its presence among waterside vegetation with its loud, raucous call.

Above: Few counties in Britain and Ireland are without water rails. Because of its generally wetter landscape, Ireland, though smaller, probably holds as many pairs as Britain, and possibly even more.

The water rail enjoys a somewhat undeserved reputation as one of the rarities among British and Irish birds. It is, without doubt, one of our most secretive birds, avoiding disturbance of any kind, and its reputation for rarity has discouraged many people from seeking the water rail, leaving it relatively undisturbed in its marshy haunts. The reputation is undeserved however, because water rails were found in 25% of the 3862 10km squares mapped in the breeding season surveys carried out to provide data for the *Atlas of Breeding Birds in Britain and Ireland*. This was far more than most bird-watchers expected, and led to estimates of a breeding population of between 2000 and 4000 pairs, comparable, for example, to our great crested grebe, heron and mute swan populations.

Watching the water rail To see a water rail well requires one or more of a number of factors operating in your favour: luck, which is probably as important as patience; a good hide overlooking a suitable habitat; or else a spell of bitter, freezing weather extending over several days, which forces hungry water rails to come out into the open to forage for

Below: A close-up view of a water rail—a rare and exciting moment.

food.

A first glimpse of this secretive bird gives the impression of a rather tall, brown moorhen. Part of this impression comes from the tail, which is up-cocked (in 'giant wren' fashion) just like a moorhen's, and which presents a bold patch of white undertail coverts to the observing eye as the tail is regularly flicked–again, like a moorhen's tail.

Unlike a moorhen, however, the water rail has a rich brown back, all the feathers having darker centres and thus giving a streaked appearance. In the adult the face, throat and belly are a pure lead-grey, a colour otherwise seen only on the breast of the dunnock among British and Irish birds. In immature water rails, and sometimes in winter adults, this grey is blotchy, with alternating pale and dark bands. The flanks carry conspicuous vertical bars of black and white that are slightly curved. The beak, considerably longer than that of the moorhen, is also slimmer and slightly down-curved. It is blood-red, with varying degrees of brown or black towards the tip.

The legs are long–hence the appearance of height–and pinkish-brown, ending in a short hind toe and three immensely long front toes. With these feet, water rails can cross soft mud and floating vegetation, and swim surprisingly well with them, too.

A marshland bird The most startling feature of a water rail is how easily it vanishes into nearby vegetation. Even if this consists of densely packed reed stems, the water rail walks straight in, without a pause, like the fabled ghost walking through a wall. A close head-on view shows the origin of this ability, as the water rail is 'compressed laterally' or flattened from side to side–a case of adaptive evolution to the habitat.

For such a skulking bird, the water rail has an extremely raucous voice and an unusually distinctive, though certainly not attractive, range of loud calls. The commonest call and, once you know it, one of the easiest ways of locating water rails, starts off like the grunting of a pig and ends in a horrific series of squeals as if that pig were being slaughtered. Other calls include a staccato 'kek-kek-kek' which may be repeated monotonously for long into the spring evening, interspersed with occasional whinnying trills that resemble those of the dabchick.

From its name, and from the structural adaptation already described, it is clear that

Water Rail (*Rallus aquaticus*): dwells in reedbeds and other dense marsh vegetation. Resident population, swollen by migrants from Europe in winter. Length 28cm (11in).

Below left: A water rail in winter. The birds clearly suffer in cold weather: they lose weight and are easier to see since they are forced to come out of seclusion to feed. Their normal diet is extremely varied, including almost any small aquatic animals from insects to fish, as well as plant roots, tubers, seeds and berries. In cold weather they venture on to stubble in search of grain, and also turn predator–reed buntings, chaffinches and wrens may come within reach of a swift dash and stab of the water rail's long beak.

Below: Looking for a nest site. As would be expected, the nest is a secluded affair deep in the vegetation, and often further concealed by being placed in the heart of a tussock of dead grass, sedge or reed. The vegetation meets in a 'roof' over the deep nest cup. Breeding begins early, with first clutches often laid at the start of April. Clutch sizes range normally from about 6 to 11 eggs; there may be two broods a year.

the water rail is a bird of densely vegetated marshland, extensive reedbeds and swamps. It is quite tolerant of brackish-water habitats such as the reed-fringed dykes of coastal marshes. Occasional pairs breed on overgrown ponds or beside meandering streams, and outside the breeding season water rails may be seen on sewage farms and watercress beds–locations where they would not normally nest.

These wetland habitats are among the most threatened parts of today's countryside. The extensive drainage, not just of marshes and fens, but also of millions of acres of sedge-covered swampy fields in the process of land 'improvement' for farming, must by now have reduced water rail numbers considerably. Certainly this reduction must be far more than has been compensated for by modern man-made wetland 'replacements' such as overgrown disused canals or gravel pits.

Intrepid flight Water rails seem so suited to life on the ground, or for occasional sorties on the water, that it comes as no surprise to see how small their wings are, nor to watch their fluttering, feeble flight, legs trailing, low over the water.

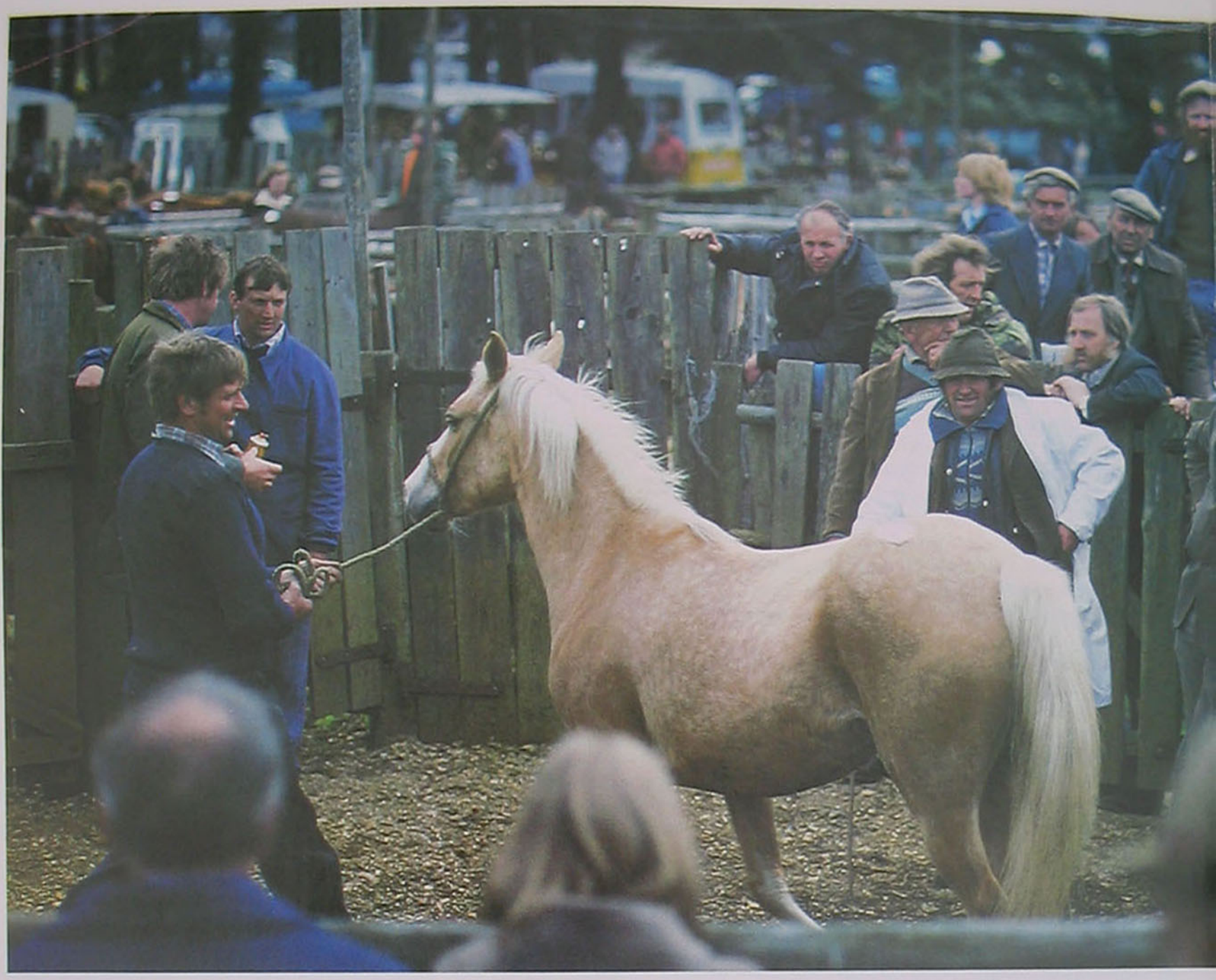
Therefore it is a surprise to discover, from the results of ringing, that the water rails on the Continent are migrants, and often long-range migrants at that. There is as yet little evidence to show whether or not British and Irish breeding birds regularly migrate, but there are now dozens of ringing recoveries showing a marked westerly or south-westerly migration of water rails from the Continent to Britain in autumn. In spring, water rails ringed in Britain during the winter are seen migrating eastwards and south-eastwards to the Continent. Some have been reported from as far afield as Sweden, Poland and Czechoslovakia.

Above: The young hatch after three weeks of incubation by both parents. They look like tiny balls of black fluffy down, alert as soon as they are dry. They are tended at the nest by both parents for the first few days, but then venture further afield in the company of one or other parent. Here the parent has found a food item to offer to the chick.

Migration mystery The fact that the birds fly south-east in spring, rather than north-east, is intriguing and difficult to explain. As a reverse of the autumn arrivals, one might reasonably expect to see the Continental water rails returning north-east and east towards Scandinavia and north Germany. Yet these mysterious ringing results are completely endorsed by accounts of birds seen at the bird observatories along the east coast: the northerly observatories all report peak numbers in autumn, while the southerly ones (particularly Dungeness in Kent) show a pronounced spring peak.

A risky life Ringing results also show a relatively short life-span for a bird of this size, for the average post-fledging survival time is about 20 months. Considering their sheltered existence and their versatility as feeders, post-fledging (and probably pre-fledging) mortality appears to be surprisingly high; this is reflected in their apparent fecundity at the egg-producing stage, which can be seen as an evolutionary response to the high mortality. Known causes of death are, as usual, varied, including a high proportion killed by predators, and the toll taken by frost and ice in winter. Among man-made hazards are overhead electric power lines.

Many birds caught for ringing are also weighed, and the water rail proves remarkable at all times of year for its extreme variability in weight. The maximum weight recorded in a recent study was 190gm (6½oz), the minimum only 63gm (2½oz). The latter was during hard weather, but otherwise it is difficult to pinpoint any single cause for such interesting variability.



HORSE DEALING: BUSTLING SALES

Horse and pony sales have been part of the British country scene for centuries. From the sale of Thoroughbred racing stock at Newmarket, where thousands of guineas change hands, to private deals at fairs, each transaction has its unique drama.

Above: A pony in the sale ring at Beaulieu Road in the New Forest. The majority of sales are of mares and foals straight off the Forest, but a small number of riding ponies and horses are also sold each year.

Horse sales range in importance from the highly organised opulence of Tattersall's Sales of Thoroughbred racing stock at Newmarket, down to deals conducted without the aid of an auctioneer in the hurly-burly atmosphere of events such as Appleby Fair near Penrith. In between are a host of other sales: of hunters at the end of each hunting season, of native ponies and, at many local stock markets, of a mixed bunch of horses and ponies that come under the auctioneer's hammer every week.

Beaulieu Road Some of the best known native pony sales are held by the New Forest Pony Breeding and Cattle Society at their Beaulieu Road saleyards near Lyndhurst in the Forest. They take place seven times a year, and most of the ponies on offer are those that have been rounded up from the Forest where they roam in semi-wild herds. The autumn sales cater chiefly for mares with foals, or for foals that are old enough to be sold without their dams.

From early morning trailers, horse-boxes and battered old lorries arrive and disgorge their cargoes of ponies. The animals are herded into a complex of pens and catalogue numbers are stuck on their backs. Commoners (whose properties carry the right to grazing on the Forest) and prospective buyers jostle each other as they lean on the pens and inspect the stock, the buyers referring to the printed catalogue, while the Commoners, whose knowledge of their own and other people's ponies is encyclopaedic, pass com-

ments from one to the other.

At the appointed time the gate opens and the first foal is ushered in and stands uncertainly, and probably frightened, because until a few days ago it had been enjoying the freedom of the New Forest with its mother. Sometimes a foal rushes into the ring and charges about until it is caught and restrained, and in the past ponies have been known to jump out of the ring, scattering the crowd in all directions as they disappear and speed back to the depths of the Forest.

Sadly, a proportion of the buyers at this and many other similar sales these days are 'the meat men' who buy animals cheaply for slaughter for the European horse meat trade or for the British pet-food trade. One of the unhappiest features of this is that they tend to buy the bigger, better foals, which, of course, have more meat on them.

Also attending these sales are representatives of various horse and pony charities who try to buy some of the ponies to save them from slaughter. It is unfortunate that, although well-intentioned, the buying of cheaper, poorer-quality animals in the long run leads to disaster: when the animals mature they are often of no use and so are sold on from pillar to post until they finally end up in the slaughter house.

It is easy and natural to be sentimental about ponies, but genuine horse-lovers would

Above right: A general view of Beaulieu Road, showing the pens and horse boxes, and the sale ring.

Below: A New Forest Pony and a Thoroughbred, showing some features to look for if you are thinking of buying one.

feel happier if charities saved their money for the better class of animal for which there is a hopeful future. It is a controversial subject, but one that is very much to the fore today at many sales up and down the country.

Rules of the game Because of continuing complaints about the indignities and, sometimes, real cruelty, that can be inflicted on horses and ponies at some of the less reputable sales still flourishing (despite the attendance of police and welfare organisations), the Ministry of Agriculture has issued a Code of Practice 'for the guidance of operators of horse, pony and donkey markets, sales and fairs'. This code does not have the force of law, although it has brought about some improvements.

The Code has 18 clauses, seven of which cover the provision of proper facilities, and the remainder suggesting rules for the conduct of sales. It suggests: that facilities should minimise the risk of injury to the animals; that they should allow easy and safe loading and unloading; that pens, boxes, etc should be of safe construction; that facilities for the separating of stallions, pregnant mares, unbroken animals, shod animals, etc should be made; that bedding, food and water should be provided for animals kept overnight; that water should always be available – and so on.

Above and below: Horses at Appleby Fair, Penrith in Cumbria. In the past many an animal has been forced to stand for hours in the river – a marvellous way of persuading swollen joints back to something approaching their normal size. At such fairs an astonishing collection of horses and ponies of all shapes and sizes change hands.

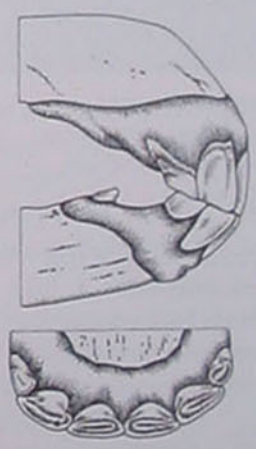
The rules for the conduct of sales state that risk of breakaways should be kept at a minimum, foals under four months of age should not be presented for sale except with their dams, competent handlers should be present, a vet should be called if a horse is ill or injured, and over-crowding should be avoided. These may all sound like common sense, yet when all these suggestions are observed, it will be a great day for the horse and pony population.

Appleby fair A different kind of selling

Below: The teeth of horses grow longer as they become older, although dishonest dealers try hard to disguise the fact.

Teeth at four years

teeth straight and short, biting surface not yet worn down



Teeth at fifteen years

teeth more angled and longer, showing signs of wear

occurs at fairs, such as the annual one at Appleby. They are often the meeting place for travellers and gypsies, and where you have gypsies you have horses, and horse dealing. There is nothing organised about the dealing at most fairs: owners trot their animals up and down the show area – often a road – to show the brilliance, or otherwise, of their paces. Many wild and demonstrably false claims and counter-claims are made about the appearance, character and performance of the animals. Bargains, once struck, are sealed by a handshake or a slap of the palm.

Let the buyer beware Dealers' tricks, much practised in the old days, and still tried by a few, have been many and varied. Many a crafty dealer has dropped a marble or two into a horse's ears – a sure way to make the unfortunate animal prick its ears and look alert. The judicious placing of a piece of ginger under the tail (known as 'figging') does wonders in persuading a reluctant horse to step out briskly. (This unpleasant practice is still used at a number of well-known European shows.)

One of the oldest tricks is 'bishopping'. The age of horses can be assessed accurately by the length of the teeth and the appearance of the cutting surface. To make an animal appear younger, dealers used to file the teeth of the lower jaw to a more youthful length, hollow them a little, burn them black to give more authenticity, then fill them with cement. This trick was named after a Mr Bishop, who is alleged to have invented it.

In many better class sales for riding horses and ponies, such as those where hunt horses are sold at the end of the season, many words or phrases used are legally binding. The most common description 'a good hunter' is a complete warranty that the animal is sound in every respect, quiet to ride and capable of hunting. 'A hunter' guarantees a little less – that the animal is sound in wind and eye, and can be ridden and hunted. 'A good performer' guarantees almost as much, while other animals sold as 'sound in action at the time of the sale' might be viewed with some misgivings by the cautious buyer. 'Believed sound' is, rather oddly, a warranty of soundness in all respects.

Above: A typical local horse sale at Henley-on-Arden, Warwickshire.

Below: There are six sales a year at Tattersall's Sale Yards at Park Paddocks, Newmarket, where horses change hands for thousands of guineas literally on the nod of a head. Tattersall's deal exclusively in racing bloodstock – Thoroughbred horses destined for the racetrack.

In addition, certain vices and conditions must be included in the official description. If the animal suffers from either 'crib-biting' or 'wind-sucking', these are regarded as forms of unsoundness. The former usually occurs in a stabled animal (but it can happen outdoors as well), which seizes a fixed object, such as a manger, with its teeth, arches its neck and swallows air, making a strange kind of grunting sound while doing so. It can lead to loss of condition, excessive wearing of the teeth, and to internal problems such as colic. Worse – other horses in the yard are likely to imitate the habit, which is difficult to cure. Wind-sucking is, in effect, crib-biting without grasping an object with the teeth. Although it does not wear the teeth, it is just as serious and is said to be incurable.

Horses sometimes have operations for various defects of their 'wind' or breathing apparatus, and this too, must be stated in the description.

The big league At Tattersall's Sale Yards in Newmarket the aristocrats of the equine world change hands for small fortunes. The facilities are luxurious for both horses, buyers, sellers and spectators – a far cry from the rest of the country's local sales and fairs. There are six sales a year at Tattersall's and the annual turnover is millions of guineas. During the last 62 years, the winners of 72 Classic races have been sold there, including twelve Derby and ten Oaks winners.

SLY CRAB SPIDERS

Brightly coloured crab spiders are often found lurking in flowers, waiting for prey. Typically squat in appearance, some of them move in a crab-like way, hence their name.

Crab spiders are attractive, medium-sized spiders belonging to the family Thomisidae. They are most numerous in the south of England and many species do not occur north of the Midlands. During spring and early summer they may be found in large numbers as they come to maturity in favoured habitats such as grasslands and along woodland edges.

However, although quite common, they are not often seen because they blend in so well with their habitat. They neither build webs nor chase prey, but tend to position themselves so that insects and other small creatures come to them. As they detect their prey through vibrations rather than by sight they can hunt in either daylight or darkness.

Camouflage tactics The crab spiders' methods of camouflage and ambush are best illustrated by the flower specialists *Misumena vatia* and *Thomisus onustus*, which wait among the petals of flowers by day for pollinating insects such as bees and butterflies to pay a visit. As soon as such prey presents its head or thorax in a position in which it may be quickly bitten, the crab spider seizes it in its outstretched front legs. The spider then holds the prey in its chelicerae (fangs) while its digestive juices circulate through the victim's body. After sucking it dry, the spider discards the empty skin.

These flower spiders are yellow, pink or white, depending on their surroundings, and

Above: This perfectly camouflaged crab spider, *Misumena vatia*, hunts in flowers. It waits among the petals with front legs outstretched, ready to seize unsuspecting prey. It also has the ability to change colour to match its surroundings.

Below: *Philodromus aureolus* a much less crab-like species, does not rely on coloration for concealment. It is an active hunter and common among trees and bushes.

they look quite spectacular when removed from their habitat. In practice, however, they rarely move far from the flowers in which they sit, unless they are forced to leave when the flowers wilt and shrivel. Crab spiders defend their territories and two spiders are never found in the same bloom–unless the second spider is a courting male.

Physical features Unequal leg lengths are a characteristic of the family. The first two pairs of legs are long and robust and heavily armed with stout spines to help hold on to the prey. The last two pairs are much weaker, but grip the substrate while the stronger legs grapple with the prey. The chelicerae, although physically weak, inject a fast-acting poison, enabling the spider to subdue much larger victims than itself.

Courtship dangers There are no visual displays in courtship for, unlike jumping spiders and wolf spiders, crab spiders do not have well-developed eyesight. Instead, using chemotactic (chemical recognition) senses, the male detects and follows silk laid down by the female, attempting to mate with her as soon as he finds her. If the female is not receptive, the male may be repelled fiercely.

When mating does take place, eggs are produced in June, their numbers depending on the female's state of nutrition. The eggs hatch in mid-summer and the spiderlings grow quickly, overwintering when they are not quite mature. They moult their final exoskeleton after emerging during the spring of the following year.

Sizes of the sexes There are 26 species of thomisid spiders in Britain and many show a considerable difference in the sizes of the sexes. Generally, males are small and slight while females are larger and more rotund. *Misumena vatia* exhibits the greatest disparity in size; the body of the female measures up to 11mm ($\frac{3}{8}$in) long, while the male's body is no more than 3-4mm (about $\frac{1}{8}$in) long.

Misumena vatia is quite common in the south of England and is relatively well known because of its ability to change its overall colour–within certain limits–depending on the coloration of the surrounding flowers. This metamorphosis is not immediate and it

Above: A crab spider can be hard to detect initially, but once spotted it can be seen day after day on the same flower, or in a particular part of a bush. *Thomisus onustus*, something of a rarity among crab spiders, is a beautiful shade of pink and merges well with the flowers of bell heather on which it is usually found.

Right: A blue butterfly ambushed by *Misumena vatia*. A flower crab spider relies on immobility to catch its prey and once caught, it holds the insect in a life-like position while it sucks out the body fluids. This ensures that the spider does not give itself away to such predators as birds. The dead butterfly is discarded with hardly any external damage.

Colourful crab spiders

Above: Female *Diaea dorsata*. Body length up to 6mm. Found in southern woods.

Below: Male *Philodromus dispar*. Body length up to 4mm. Found in gardens, sometimes in houses.

Right: Female *Xysticus lanio*. Body length up to 7mm. Found on young oak tree foliage.

Left: Female *Philodromus fallax*. Body length up to 5mm. Found on grassy sand dunes.

Above: There is a great disparity in the sizes of male and female crab spiders. The bulky female *Thomisus onustus* may reach 8mm ($\frac{3}{10}$in) in body length, but the male is only 3-4mm ($\frac{1}{8}$in). He tracks down the female by the silk lines she has made, but is in danger of his life if she is not receptive to mating.

Left: A female *Xysticus cristatus* standing guard over her egg sac. The eggs are laid in June on a bed of silk and usually number about 45, although some of the larger species lay as many as 100. More silk is put over the top of the woolly egg cocoons, and the female stays with them until they hatch in July.

takes a few days for the spider to change from, say, white when among hawthorn flowers, to yellow when hunting in gorse or broom.

The males, which do not rely on camouflage for hunting, have strikingly patterned legs and a pair of dark bands over the greenish-white abdomen. Both sexes may be seen in May and June, but it is rare to find any surviving adult females by July.

Pink rarity Our second flower-adapted species is the uncommon *Thomisus onustus*, which is found on southern heathlands. It is usually pink, blending well with the flowers of bell heather among which it lives.

Like *Misumena vatia* the female *Thomisus* is much larger than the male and feeds mainly on flying insects. However, it differs somewhat in appearance; the outer eyes are placed on prominent tubercles or protuberances and the rear corners of the abdomen are shaped into distinctive conical humps. Maturation, mating and egg-laying all take place about one month later than in *Misumena*, because of the later flowering season of bell heather.

Varied colours The colourful *Diaea dorsata* is found in southern woodlands–often in large numbers–during May and June. It favours the foliage of trees and bushes such as oak, yew, box and birch. Although brightly coloured, it is well camouflaged and feeds on small, soft-bodied insects such as greenflies.

Crab spiders of the genus *Xysticus* are recognised by the leaf-like pattern on their abdomen and a wedge-shaped mark on the cephalothorax. The females are usually sober in coloration, but the males may be vividly patterned. *Xysticus cristatus*, the most common species, is found on bushes and low herbage throughout the countryside, while other species are not so widespread.

Swift-running spiders Once classified as part of the Thomisidae but now recognised as a separate family, the Philodromidae comprises 15 species of crab spider in Britain. These spiders are much less crab-like in appearance than the Thomisidae and are active hunters, with thick pads of hair on their feet to increase adhesion when running on the underside of leaves.

The coloration of some species makes them inconspicuous in their habitat. The coastal *Philodromus fallax*, for example, blends in with the sand on the grassy dunes of its home, while the more colourful *Philodromus histrio* harmonises well with the heather shoots on the heathlands it inhabits.

In contrast, the two most common species of *Philodromus* appear to have forsaken camouflaged coloration. The distinctive and abundant *Philodromus aureolus* can be found on the foliage of trees and bushes throughout the country in the spring and early summer. *Philodromus dispar* is common in gardens and often strays into houses, where the long-legged male can be recognised by his iridescent black body.

The mating trap

Xysticus cristatus has unusual mating behaviour. The small male seizes the female by a leg and holds on until her struggles cease. He then moves round her, tying her down with silk so that she can't attack him. Tilting her abdomen upwards he moves below to mate, applying both palps (male sperm-storing organs) alternately to her epigyne (female opening).

CONSERVATION ON A DAIRY FARM

Kingston Hill is one of ten farms involved in the Demonstration Farm Project–a scheme devised by the Countryside Commission to exhibit techniques whereby efficient agriculture can be successfully combined with conservation on marginal farm land.

Above: Kingston Hill Farm has 350 Friesian dairy cows, 200 'followers' or young cows yet to enter the milking herd, and 300 beef cattle. They are fed on protein-rich grass and silage, and a field of spring barley is grown to provide them with an 'energy' supplement to this basic diet. There is no Friesian bull on the farm; his services are provided by artificial insemination, by courtesy of the Milk Marketing Board. Thus the farm has access to the best Friesian blood available.

Kingston Hill is a dairy farm occupying 294 hectares (726 acres) in the upper Thames valley near Oxford. Most of the land is sown with grass, which provides both summer pasture and winter feed for up to 850 cattle. The stocking rate is nearly three animals to the hectare; to maintain them all in proper condition the land must be kept in good order, and there is no room for systems of management that may jeopardise productivity. Nevertheless, the farmer, as part of the Demonstration Farm Project, is able to combine a certain amount of conservation of wild species with good farming practice.

The pastures By mid-summer most of the grass at the southern end of the farm is starting to recover from the first silage cut of the season. Mown as if for hay, the grass is left to wilt for a few hours to reduce its moisture content, then gathered with a forage harvester which chops it up and blows it through a tall curved spout into a trailer. At the farmstead the chopped grass is accumulated in a heap, or silage clamp, compressed to exclude the air, and covered in plastic sheeting weighted down with old motor tyres. Preserved in this way–in effect a form of canning–the grass feeds the cattle throughout the winter.

To achieve maximum food value from the grass, essential for a high-yielding dairy herd, most of the fields are sown with a carefully selected ley–a mixture of grass species including ryegrass, timothy and cocksfoot. After a few years, when productivity declines due to invasion of undesirable species, or to destruction of the sward by the hoofs of grazing cattle, the ley is ploughed up and used for arable cropping. At Kingston Hill the stored fertility of the regular grazed grassland, augmented by a dressing of slurry from the cattle yards, is used to grow a cash crop of wheat before reseeding with grass.

The farm road ascends a gentle slope to an area of drier land, where there is an uncut ley consisting largely of cocksfoot. This deep-rooted grass is particularly tolerant of drought and usually does well.

The grass itself is fertilised by the cattle and

Above: Hedges have been allowed to regenerate between double fences at Kingston Hill, in one case preserving a Saxon parish boundary. Dog roses (shown here) flourish along these boundary hedges.

Opposite: Cornfields ripening in July. In addition to wheat, the farm grows barley and even maize. The maize is grown in summer on a field that has light, well drained soil; although it does not ripen properly in the British climate, it is a useful crop in a dry season and, when chopped up, the whole plant makes excellent silage for the cattle.

Below: Kingston Hill is proud of its badgers; unlike the dairymen of the West Country, Thames Valley farmers have no reason to suspect these wild mammals of carrying bovine tuberculosis.

by regular applications of artificial fertiliser. Originally broadcast by a spinner device, much of the fertiliser finished up in the hedges, upsetting the hedgerow ecology and wasting valuable money. The spinner has now been replaced by a precision applicator; herb species in the hedge are flourishing and the initial equipment cost will soon be offset by material savings.

In a corner by the farm buildings a chance find while digging a drain has revealed the site of a Roman villa. Partially excavated, recorded and re-buried, the site is now preserved from plough damage by being maintained as long-term grassland.

The dairy herd Beyond the farmstead you may well find the dairy herd gathered round a drinking trough. A dairy cow drinks a minimum of 22 litres (39 pints) a day, usually much more, and water is piped to every corner of the farm. This has made the old farm ponds redundant; many farmers would fill them in, but at Kingston Hill time has been spent in clearing them out to form nesting sites for moorhens and wild duck, and a habitat for frogs, newts, and water plants such as bur-reed and amphibious bistort.

The cattle are Friesians. They are the most popular dairy breed in Britain, partly because of their excellent milking performance – on this farm the average yield per cow is 5000 litres (1100 gallons) a year – but also because superfluous animals can be fed up to produce plenty of lean, attractive beef. Each cow must have a calf before she can be milked; half the calves produced each year will be male and of no use to the dairyman, so it makes sense to use a breed that will fetch a good price at market. Female calves sired by a purebred dairy bull may be reared to join the milking herd.

Every day the dairy herd is moved on to a new ley. By the time they have been right round the farm, the grass in the first field will have grown again, and any parasites left there will have died. The dairy cows get the pick of the grass; they need it to keep up their milk yield. Dry cows, resting for two months between lactations, do not require this 'production ration'; fed for maintenance only, they commonly follow the main herd, finishing off the leftovers.

Flood meadows Beyond the winter wheat at the end of the farm road, a band of flood meadows lines the south bank of the river. Too wet for arable cropping, they are maintained as permanent pasture. Such grassland has a much richer flora than a ley, but the nutritional value of the assorted herbs and grasses is inferior. Despite this, there is very little agricultural advantage in ploughing and reseeding; the dense, resilient turf built up over the years is a valuable asset on such wet land. The meadows make useful grazing for dry cows and young animals, and their botanical diversity, coupled with the presence of a number of pollarded willows, enhances the riverside landscape.

The meadows are separated from the main part of the farm by a substantial flood relief channel. Together with the ditches draining the heavy clay, this is important as a habitat for wetland plants and animals, such as rushes, yellow flag, tadpoles and dragonflies, and as a route through the farm linking the ponds with the river. For these watercourses to remain effective, they have to be periodically cleared. On most farms the whole network would be dredged out in a few days, but here the ditches are dealt with in rotation, so that there is always a refuge for displaced wildlife. Spoil is dumped on one bank only, ensuring that the vegetation on the other bank remains largely undisturbed, thus encouraging comprehensive recolonization.

The durability of permanent pasture can be very useful in early spring when the dairy cattle are turned out from the covered yards. Still wet from the winter rains, the main grazing leys are too soft to bear their weight, so they enjoy their first taste of spring grass from the well-established turf of a number of small fields near the farmhouse.

Coppices for shelter and profit Shelter is an important consideration in winter and early

Above: Game birds such as pheasants are preserved at Kingston Hill—just another of the many small sidelines run on the farm. As a whole, conservation measures on this farm have incurred a capital expenditure of about £2000, two thirds of which represent the cost of tree planting, a source of future income. Productivity losses and management costs have been negligible—the benefits to a wide variety of wild flora and fauna incalculable.

spring, and the blocks of woodland enclosing the fields perform a valuable function as windbreaks. Severely hit by Dutch elm disease in the early 1970s, these woodlands have been cleared up and restocked.

One rather wet area has been planted with a potentially valuable crop of cricket bat willow, but most of the woodland is managed as ash and hazel coppice, with oak and ash standards. The woodlands are naturally of considerable wildlife and landscape value. They provide sites for many of the 64 species of bird known to nest on the farm, including the great spotted woodpecker; and early purple orchids flower among the undergrowth.

Dutch elm disease has completely changed the aspect of Kingston Hill. The loss of trees which had proliferated by suckers along the hedgerows opened up the landscape, and in some ways improved it. Nevertheless, the general policy has been to replant with other species, such as oak, lime, cherry, crab apple, hawthorn and hazel, particularly where the original elms formed a shelter belt.

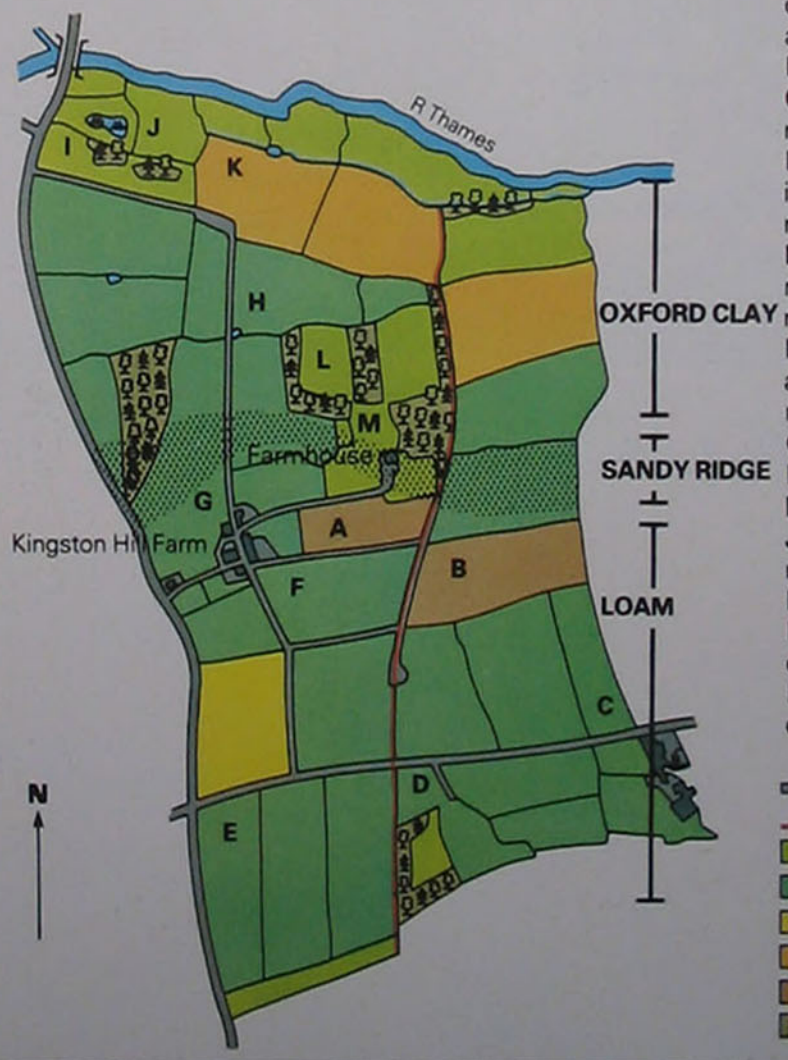
Hedges A conservation technique particularly favoured on the farm is the encouragement of natural regeneration between double fencing. It has been used to good effect in the preservation of the old parish boundary which, dating from the Saxon period, is both a major historical feature and an important wildlife corridor running from north to south right through the farm. Some of the animals it harbours, however, are less than welcome; strict control measures are taken against rabbits, which are an agricultural pest.

All down the boundary the hedges are bright with flowering dog rose and bramble, the blooms attended by speckled wood, peacock and small tortoiseshell butterflies. These have plenty of scope for breeding in the band of nettles, thistles and uncut grasses left at the edge of the grazing leys where they can do no harm. Such 'enlightened untidiness' is characteristic of the approach to conservation at Kingston Hill, costing nothing but a little thoughtfulness and a reassessment of the farm's priorities.

Kingston Hill Farm

Kingston Hill Farm is being run as part of the Countryside Commission's Demonstration Farm Project. This was set up in 1965 with the aim of assessing if and how commercial farming and conservation practices could be integrated. This farm is owned by St John's College, Oxford, and Mr Poul Christensen has been the tenant since 1968. The northern part of the farm is on Oxford clay, while the southern areas consist of fine sandy loams and loams. The business is based on a large dairy herd, but beef cattle are also kept, and some cereals are grown.

The Living Countryside would like to thank Poul Christensen, farmer, and Russel Matthews, Assistand Project Officer, Cobham Resource Consultants, for their help and advice in preparing this article.



A Farming on clay land; creating a new landscape; amenity tree planting.
B The parish boundary.
C Back fencing to aid regeneration.
D The Green Lane—an important habitat; woodland reclamation.
E Farming on the light land; new farm buildings; concrete roads; hedge management.
F Archaeology and agriculture; slurry disposal; new farm buildings.
G Tree planting.
H Pond/ditch management.
I Hedge management.
J Scrub management; recreation on the farm.
K Pond/ditch management.
L Woodland reclamation; experimental tree planting.
M Woodland management; coppicing.

concrete road
parish boundary
permanent pasture
ley
spring barley
winter wheat
maize
woodland

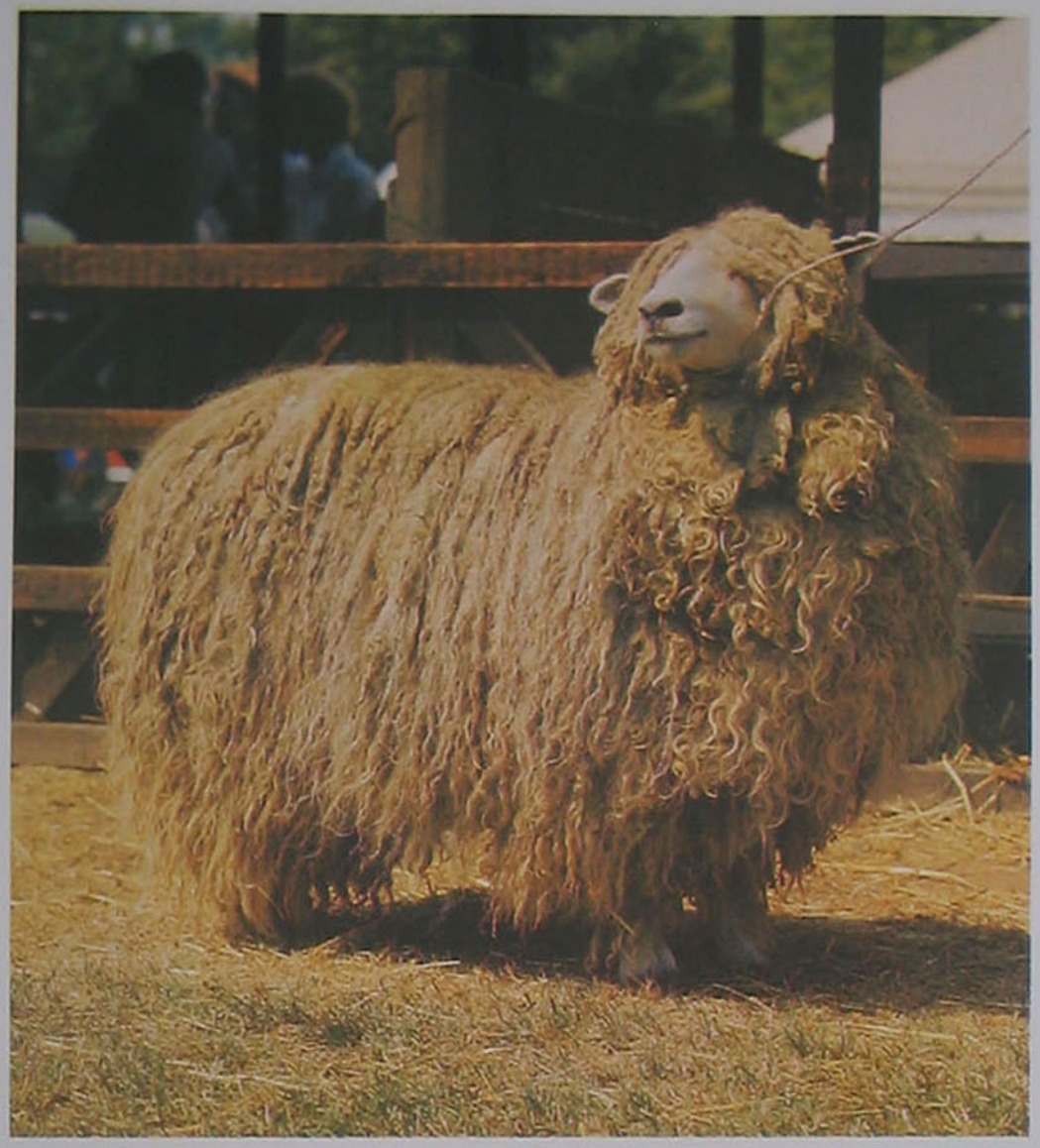
OLD WEALTH: LONGWOOL SHEEP

Longwool sheep, such as the Leicesters shown below, were introduced by the Romans and are found today in localised areas of rich land around many of the old Roman settlements. Valued in the past for wool and milk, they now exist only in small numbers.

The sheep industry in Britain differs from that in many other parts of Europe and the rest of the world. In Britain the main product is meat, but in much of Europe, and also in the developing countries of other continents, the production of milk and wool remains the primary purpose of sheep.

Changing markets Sheep in Britain have changed with the development and demand of the market. In the Middle Ages milk was the most important product gained from sheep, but later wool manufacture became one of the main industries in Britain and was the source of considerable wealth in many different parts of the country.

Since the Industrial Revolution, however,



Above: The Lincoln is a massive sheep that produces the heaviest fleece with the longest staple (the technical term used to describe the group of fibres that hang together in locks of any breed in the world). The pelt is in great demand for the manufacture of sheepskin products. The lambs are also valuable: they are heavy and ready for slaughter at high weights at about ten months of age.

the emphasis has switched to meat production, and many breeds which had enjoyed great popularity when milk and wool were in demand decreased in numbers and were in danger of disappearing altogether. The longwool breeds, in particular, suffered during this change in demand. Almost all the longwool breeds in Britain now exist only in very small numbers. They have adapted to some degree to the requirements of a meat production system, but they do not compete effectively against the popular specialist breeds.

Longwool sheep were introduced to Britain by the Romans and kept in areas which were the centres of Roman settlement. They displaced the native primitive sheep, which retreated to the higher, less fertile ground, particularly the northern and western areas of Great Britain. Today the longwool breeds are still found in localised areas which correspond roughly to the places where they became established in Roman times. As a type, they are large, heavy animals, needing rich land and good feeding to realise their full growth. Britain's damp climate and the strong loam soils in the lowlands were an ideal environment for these animals, which in previous centuries were famous throughout the world.

The Romney Marsh The most popular longwool breed in Britain at present is the Romney. It inhabits the south-eastern corner of England, the area first invaded by the Romans. It has become adapted to the cold, wet environment of windswept Romney Marsh, and its long wool is an ideal protection against the inclement conditions of the area.

Although it has been exported to other countries, notably Australia and New Zealand, it has not spread to other parts of Britain and remains a rather untypical animal within the longwool group. Whereas other longwool breeds have developed their productive qualities in some way, the Romney has relied for its continued popularity largely on its adaptation to its special environment.

The Lincoln Breeds of livestock as readily recognisable groups began to emerge significantly in the 18th century. Before then only a few distinct breeds or types existed. Among the longwool breeds the Lincoln and the Teeswater were the earliest to be recorded in agricultural literature.

The Lincoln is a massive sheep, producing the heaviest fleece with the longest staple of any breed in the world. Its home territory is the rich lowland pasture of the county from which it takes its name. The lush grazing permits great growth of bone and wool. Throughout the Middle Ages the fens and pastures of Lincolnshire supplied the wool for the looms in Norfolk, which were famous in most parts of the world.

The breeders of the Lincoln naturally placed the greatest emphasis on breeding for the production of wool, and at the same time tended to neglect the qualities of the carcase.

Romney Marsh
Weight of fleece 4kg (9lb)
Length of staple 17.5cm (7in)
Wool quality48–54

Lincoln Longwool
Weight of fleece 6kg (13½lb)
Length of staple 35cm (14in)
Wool quality 36–44

Leicester Longwool
Weight of fleece 5.5kg (12lb)
Length of staple 25cm (10in)
Wool quality 40–46

Thus the Lincoln's yield of wool increased, but the conformation of its body grew gaunt and coarse.

When the value of the wool decreased the breeders belatedly made some attempt to change the form of the breed and to remedy its defects of conformation. Today it is still one of the largest sheep in Britain, but its shape is more compact. It has a broad back with a strong frame and large bones. Its head is wide with long ears and a forelock of wool hanging over its face. However, wool is still its most highly prized product. It is valued for its length of staple, lustre and strength, which impart special qualities to yarn and fabrics made from it. Its quality of curl and lustre have proved valuable in the manufacture of coats. This breed is rare in Britain today, although relatively common in South America and Eastern Europe, and it has contributed to several modern breeds in New Zealand and Australia.

The Teeswater The fertile valley of the Tees in Northern England, the home of several improved types of livestock, was the home of the Teeswater sheep. It developed from the same basic stock as the Lincoln. Two centuries ago it was a tall, heavy, clumsy animal, with little to recommend it in its appearance. Its wool was long, but there were fewer fibres per unit of area of skin than on the Lincoln, so the weight of the fleece was relatively light for so large an animal. The one redeeming feature of the breed was that it was outstandingly prolific, a quality that attracted special mention as early as the 18th century when an ewe produced 16 lambs in four years. Since that time the breed has retreated inland from Tees-side up the valley to Teesdale, but it has retained its prolific qualities.

Today the Teeswater is a medium-large sheep, producing a heavy fleece of long wool that hangs in ringlets and is free from coarse fibres. The head is large, hornless and light-coloured with a darker nose. It is found only in a small area of Britain and has not been exported.

The Leicester Longwool In contrast to the Teeswater, the influence of the Leicester Longwool has been felt in many parts of the world. Originally, the native sheep of Leicestershire were comparable in type with, but rather smaller than, those found in Lincolnshire. Wool was their main product. However, the breed became the focal point of the breeding programme developed by Robert Bakewell in the late 18th century.

Bakewell transformed the coarse, ungainly sheep with a heavy fleece of long wool and little capacity to produce meat, into a breed which became renowned for its ability to yield meat. In order to cater for the demand created by the Industrial Revolution, Bakewell emphasised the early maturing qualities of the breed, so that it yielded a carcase of high quality, which at that time required a considerable content of fat. In the process of this transformation the Leicester sacrificed its prolificness, milk yield, and some of its wool production, but it suited the requirements of the time so well that it was used to improve almost every other longwool breed in Britain. When fat became undesirable it lost its popularity, and is now found mainly in the wolds of Yorkshire and North Humberside.

The Wensleydale The Wensleydale is a descendant of the Leicester. The breed was

Above: Border Leicesters are a popular modern breed of sheep descended from the Leicester Longwool and developed on the Scottish borders.

Below: Longwool sheep, showing the weight of the fleece of a mature ewe in each breed. The quality number, sometimes referred to as the Bradford Count, indicates the number of hanks into which a pound of wool could theoretically be spun—the higher the rating, the finer the wool. The Lincoln is not only the oldest and largest of the longwool breeds, but it is Britain's biggest sheep and has distinctive woolly legs.

Cotswold
Weight of fleece 5.25kg (11½lb)
Length of staple 22.5cm (9in)
Wool quality 40–46

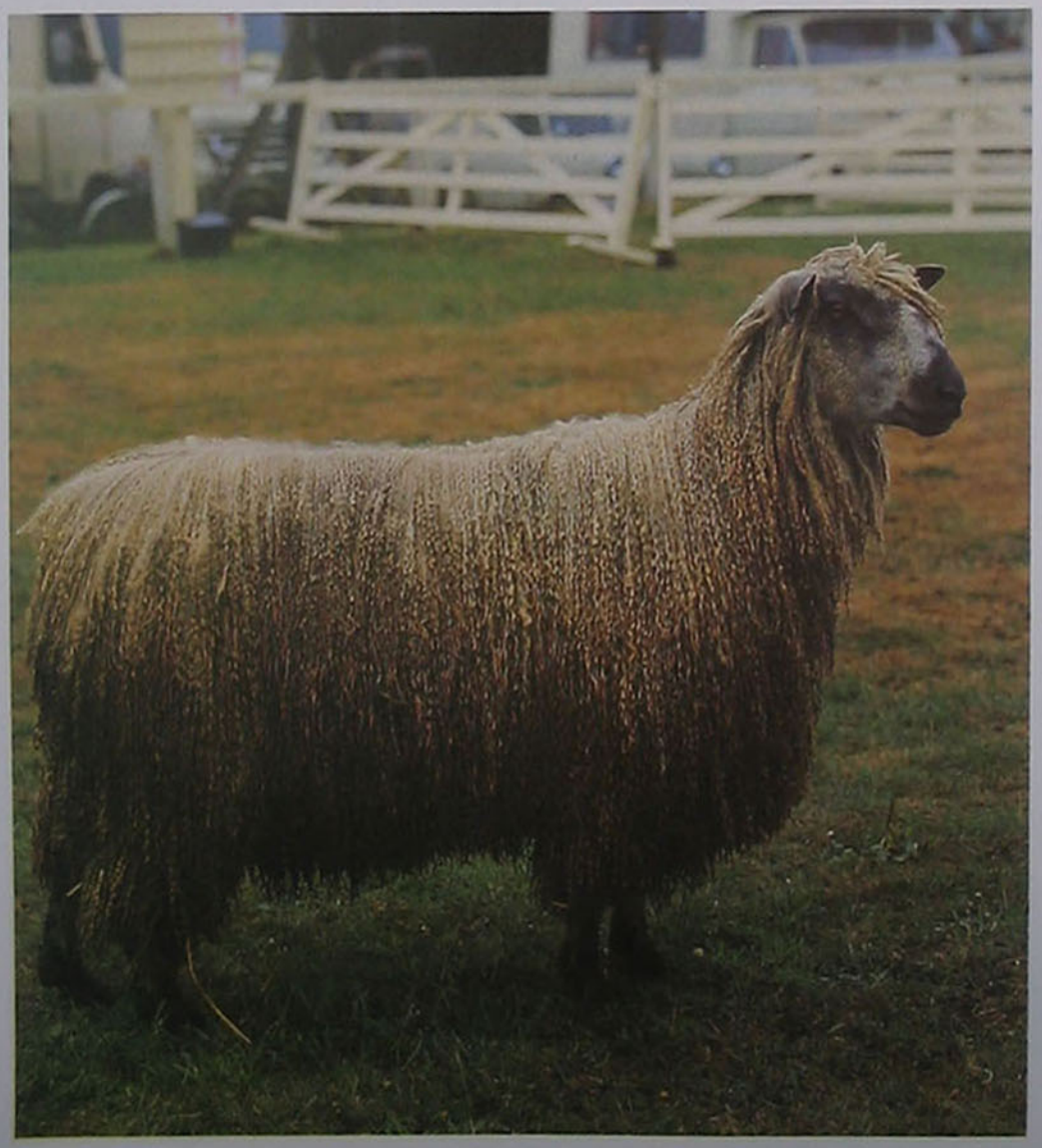
Wensleydale
Weight of fleece 6kg (13½lb)
Length of staple 27.5cm (11in)
Wool quality 44–46

Teeswater
Weight of fleece 6kg (13½lb)
Length of staple 27.5cm (11in)
Wool quality 40–48

Above: Cotswold sheep are still largely restricted to their native area and kept by only a few enthusiasts.

Left: The Wensleydale, with its high quality wool and growth rates, also produces lean meat, and its numbers are increasing once again.

Below: The Teeswater is notable mainly as a sire of the Masham, a popular crossbred ewe.



founded by a ram called 'Blue Cap', the product of mating a Leicester ram and a Teeswater ewe. Blue Cap took his name from the deep blue colour of his head, and this strong pigmentation of the skin has become a hallmark of the breed. It is found mainly in the Yorkshire Dales.

In the early 20th century the Wensleydale was used to sire prolific crossbred ewes, notably the Masham. However, after it was superseded in this function by the Teeswater, its fortunes declined rapidly. By the late 1970s only a small remnant of the breed existed.

The Wensleydale probably reflects better than any other breed the development of Britain's sheep industry. Initially it was kept by monks in Yorkshire and used for milk and cheese production. Later the wool was found to possess special qualities – it is long, highly lustrous, and hangs in tight ringlets; it also has a unique characteristic known as 'central checking' which eliminates all coarse kemp fibres. When Wensleydale rams are mated with the wool-less Wiltshire Horn, or even with hairy African sheep, the crossbred progeny grow fleeces which are entirely free from kemp, an improvement otherwise beyond the powers of even the fine-woolled Merino. The long, lustrous wool of the Wensleydale is valuable for tapestry work.

In addition, this breed has probably adapted best of all the longwools to the requirements of meat production, achieving high growth rates and producing lean meat. Its pigmented skin gives it protection in hot climates. Its accumulation of valuable qualities is at last being appreciated by flockmasters, and its numbers are increasing once again.

The Cotswold The Cotswold is also associated with the wool trade in the Middle Ages. Cotswold fleeces provided the wealth that built many of the fine stone churches and manor houses still existing in the Cotswold hills today. The breed probably originated from sheep kept on large Roman estates in Gloucestershire, but it is unusual among longwool breeds because it evolved in an area of thin soil, whereas big sheep tend to be associated with rich, fertile land. Cotswolds were numerous until the 19th century, but after World War II the breed was reduced to one flock.

The Cotswold today is a large sheep, similar to the modern Leicester Longwool. Leicester rams have been used frequently to improve flocks of Cotswold sheep. The wool is long and wavy with an open staple. Traditionally, when the sheep are shorn the forelock is left unclipped and hangs down the face. The head is broad, hornless and white or grey in colour.

The Cotswold is still restricted largely to its native hills. Like the other longwool breeds, its qualities have been out-dated by the progress of the sheep industry, and it is sustained only by loyal enthusiasts who hope that future changes in demand may once again restore popularity to their chosen breed.

Above: A male red-backed shrike is easy to identify by his dark, piratical eye stripe. Although the male may perch conspicuously on a post, pole or bush, his song is not very loud or distinctive, generally consisting of nothing more than a diffuse jumble of warbles.

Red-backed shrike (*Lanius collurio*). Passage migrant and summer visitor. 17cm (6¾in) long.

RED-BACKED SHRIKES: A THREATENED FUTURE

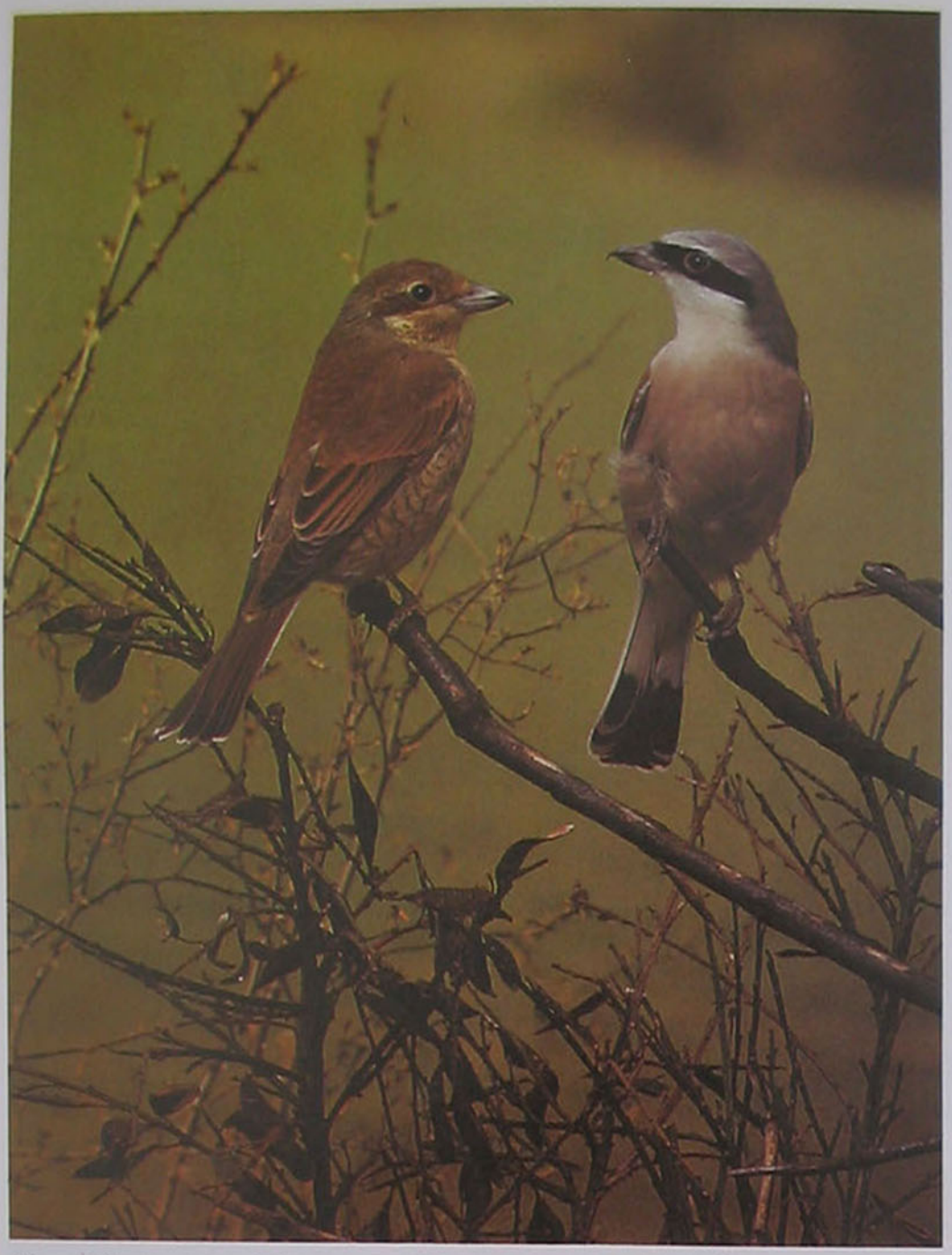
The fate of the red-backed shrike in Britain hangs in the balance. There is hope that some birds will remain in their traditional breeding areas in south-eastern England, and there is always a chance that a pair arriving from Scandinavia to breed here may build up a sparse but regular population.

The male red-backed shrike is an exceptionally striking bird, with chestnut back, blue-grey head and nape, and a broad dark stripe through the eye. The female is brown above and buff below, while the youngsters are liberally barred above and below. In size these shrikes are rather bigger than a greenfinch, but with a longer and broader tail which they often flick from side to side.

In Britain these birds are summer visitors or passage migrants and have seldom been recorded here earlier than the end of April or later than the start of October.

Fall and rise? Fifty years ago the red-backed shrike was a familiar member of the bird community over much of southern Britain. Unfortunately, over the last few decades the species has become scarce, and many ornithologists felt that it would become extinct in Britain before the end of the century.

Now it seems that this is unlikely. As the decline set in, the population seemed to remain fairly high in the Brecklands and coastal heathland areas of East Anglia, and in parts of Kent and the New Forest. (The birds prefer scrubland and heathland, although, when they were common, they would nest in hedges in farmland and even in gardens.) During the 1960s even these last strongholds started to lose their birds, and a disastrous decline in the New Forest reduced that population from more than 60 pairs to less than 10.



Above: Among the shrikes only the red-backed shows marked differences in plumage between the male and the female. The male's chestnut, blue-grey and black colouring is rather conspicuous, while the female's brown and buff is much more discreet.

However, over the last few years there has been distinct cause for optimism. Although the number of pairs known to be breeding each year has remained below 50, their distribution has become much wider. Odd pairs have been found in several counties where none had bred for 20 years or more, and there have been breeding season records in Wales and several in Scotland where there had previously been very few attempts at nesting. These records have been interpreted not as an increase in the traditional population, which had inhabited Britain for centuries, but as an expansion in range on the part of the Scandinavian breeding birds.

Reasons for the decline The reasons behind the long-standing decline of the red-backed shrike are not well understood. The bird is a predatory species, feeding mainly on large insects – particularly beetles, butterflies, crickets and grasshoppers – all creatures whose populations have undoubtedly declined considerably. This is almost certainly due principally to gradual and subtle changes in climate, but the introduction of new and more poisonous insecticides cannot have helped.

The gradual loss of scrub habitat has also been blamed, but this does not seem very likely: many suitable sites have lost their shrikes although their ecology seems to have changed but little. Another factor is that the red-backed shrike does lay extremely attractive eggs which show a great deal of colour variation; this has made them a particular favourite among egg-collectors. It seems likely that local populations were wiped out completely through the activities of collectors – who are known to have been busy in recent years even though the species has been given special protection since the revision of the Bird Protection Act in 1967.

Nesting and rearing young The red-backed shrike arrives in Britain to breed (or on passage) during the month of May. The male may be very conspicuous, perching high in a bush, on wires or on a post or pole. Even at a distance, his characteristic bouncing flight, with an abrupt upwards sweep to land on the next perch, can give his presence away.

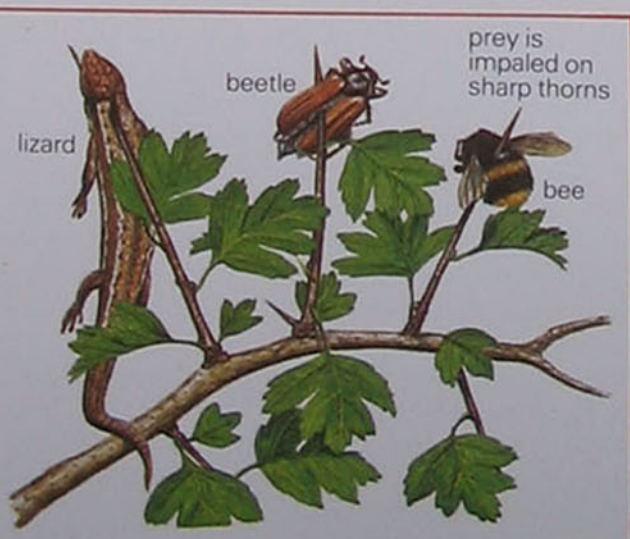
It is, however, quite possible for breeding birds to conceal themselves from view throughout the whole of the first part of the breeding season. The nest is a fairly large structure, often built in the midst of thick cover and generally a metre or so from the ground. The eggs show a wide variety of ground colour, with reddish markings often concentrated at the blunt end. The full clutch is generally of five or six eggs; they are incubated, mainly by the female, for about 15 days. The chicks fledge after a further two weeks.

The butcher bird's larder One of the most interesting aspects of red-backed shrike behaviour is the formation of larders – an aspect which has earned it the name of 'butcher bird'. The larders are stores of food apparently made mainly by the male at the start of the breeding season. Not all males do this and it used to be thought that the food was being stored for the incubating female to eat or to give to the chicks. It now seems more likely that the male is demonstrating his ability to catch food, as shown by a well-stocked larder, to attract a female.

As well as the large insects already mentioned, the shrike also catches mice, shrews,

The shrike's 'larder'

The 'larder' of the male red-backed shrike is a gruesome sight; it can consist of lizards, bees, wasps, beetles and other insects, and even of a mouse or small vole. It is thought that the male makes these stores of food as much to attract a female and induce her to mate with him as to feed her and the hungry chicks. Females rarely make such larders.



lizards and even birds. A wide variety of prey species has been recorded, often at the larders where the food is impaled on thorns or barbed wire. The bird's hooked beak, just like that of a miniature hawk, is well-adapted for catching such food, although the shrike has not developed similar talons for gripping prey.

Shrike or warbler? Once the young shrikes have fledged, there is no chance of concealment. The whole area within a few dozen metres of the nest reverberates to the incessant harsh 'tchack' calls of the young as they beg for food from their parents.

The youngsters bear an extraordinary resemblance to the adult barred warbler – a large relative of the whitethroat, found in eastern Europe and parts of Asia. Both birds may be found in Britain on the east coast after south-easterly winds in September; they sometimes provide an interesting problem in identification. What is even more surprising – since they are not at all closely related – is that the two species seem to have a nesting association, at least in parts of Poland where their distributions overlap. Out of 21 shrike and 20 warbler nests studied, 11 were close together, sometimes with complete overlap of territories. The shrikes often chased other birds from their territory, but tolerated the barred warblers. It is thought that the two birds benefit from mutual warning of danger from predators.

The shrike is, in fact, a particularly good indicator of the presence of other birds of prey. The professional hawk catchers of medieval times in Holland, Belgium and other countries used to tether a shrike by their nets to tell them when a hawk was in the area. The shrike would see the hawk when it was a very long way off and start to flutter and call. This would be the signal for the catcher to manipulate his decoys and try to catch the approaching hawk or falcon.

Autumn migrations In the autumn British red-backed shrikes migrate south-east to winter in Africa, crossing the eastern end of the Mediterranean on their way. In east Africa, in Kenya for instance, they find large tracts of suitable land for wintering, with bushes and isolated trees and good supplies of large insects. Here they are joined by other shrikes from Europe and western Asia.

There is considerable variation in plumage between different populations of red-backed shrikes: all the way across the mid-southern area of Asia the species is known as the Isabelline shrike, while in the west it is called the brown shrike. In south-west Europe, where the red-backed shrike does not penetrate, its place is taken by another species, the woodchat-shrike.

The future? In Britain the fate of the red-backed shrike is uncertain. Ornithologists hope that some birds will remain in their traditional breeding areas in south-eastern England, provided that the reclamation of heathland for farming does not consume all the suitable sites. Elsewhere, the occasional pair from Scandinavia may arrive to breed somewhere along the east coast of Britain.

Above: Shrikes are birds with striking colouring, hook-tipped bills and the habit of impaling prey on thorns, forming 'larders'. The red-backed is a summer visitor and passage migrant here, while the woodchat-shrike and the lesser grey shrikes are rare vagrants. The great grey shrike is an autumn and winter visitor.

Below: A female red-backed shrike feeding her young at the nest. Both male and female birds feed the chicks as they become older, but at first the cock bird brings food for the hen to give to the young.

NATIONAL FLOWERS: SYMBOLIC SPECIES

The flowers which have been used for centuries as national emblems have fascinating stories associated with them. Legends link them with subjects as diverse as wars and invasions, kings and saints and even the Holy Trinity.

Above: The Scottish emblem is probably not the species called the Scotch thistle (*Onopordium acanthium*)—which is, confusingly, rare in Scotland—but the spear thistle (*Cirsium vulgare*), shown here. In flower from July to September, this common species is impressively armoured—each leaflet is spine-tipped and the stem has spiny wings. Even the flower head is surrounded by scaly bracts with spiny tips which curve outwards.

Flowers are frequently adopted as symbols and emblems for a variety of purposes. Each country of Great Britain has its own national plant, and the choice of each of these has a legend associated with it.

Symbolic roses The rose has been used as the emblem of England since Tudor times, when the Tudor rose was produced as an amalgamation of the symbols of the royal houses of York and Lancaster.

Roses were frequently grown in medieval gardens, and were selected as symbols by the rival claimants to the English throne during what was later called the Wars of the Roses. The Wars were fought for a period of 30 years during the 15th century between the houses of York and Lancaster. During the battles, the soldiers of each house recognised one another, and the enemy, by the emblems they wore on their caps. The house of Lancaster adopted the red rose or Rose Gule, while the house of York chose the white rose or Rose Argent. The wars were responsible for the deaths of over 80 princes, many noblemen and more than 100,000 common soldiers and so there was great rejoicing when they came to an end with victory for the house of Lancaster and the union of the two houses by the marriage of Henry VII of Lancaster (Henry Tudor) to Elizabeth, heiress of the house of York. After the marriage, a new symbol incorporating both the red and the white rose was adopted, later to be known as the Tudor rose.

Legend has it that a rose bush in the grounds of a Wiltshire monastery bore both red and white flowers during the Wars of the Roses. On the marriage of Henry and Elizabeth, the bush bore roses with pink and white striped petals, thought to be symbolic of the harmony achieved by the union of the two rival houses. In fact, a cross between the roses of York and Lancaster does produce a pink and white striped rose.

Prickly emblem The flower most associated with Scotland is, without doubt, the thistle although there is some doubt as to which species it represents.

Several tales describe the origins of the Scottish emblem. The simplest is that during the invasion by the Danes in Saxon times, the Scots chose to wear the thistle, which grew abundantly, to distinguish them from the Danes. However, a more colourful tale tells how the Danes were making a night attack on their enemy. As they crept barefoot into the Scottish camp an unfortunate soldier put his foot on a thistle, and his screams aroused the Scottish troops. The Scots, alerted to the danger, were able to attack and defeat the enemy, and adopted the thistle as their emblem as a result of their success.

The leek or the daffodil? Two emblems are considered appropriate to Wales, although only one, the leek, seems to have legends associated with it.

The leek (*Allium ampeloprasum*) was probably introduced to Britain and Europe from the near East by the Romans. Legends concerning the leek date back to St David, the patron saint of Wales, who was born around 520AD in what was then Pembrokeshire. One story says the leek was chosen as a tribute to the hermit-like life of St David as 'he did feed only upon the leeks which he gathered in the fields'. Another tale has it that the leek was used as a means of identification by St David, who ordered all his soldiers to wear leek leaves in their caps, to distinguish them from the invading Saxons. Thus the Saxons slew both friends and enemies in the course of battle, while the Welsh soldiers, with their badges, avoided slaying their comrades.

Left: *Rosa* × *alba*, the white rose of the house of York, is a hybrid species probably produced from the introduced rose of the house of Lancaster (*Rosa gallica*), shown right, and such wild species as the field rose (*Rosa arvensis*) and the dog rose (*Rosa canina*). If these red and white roses are interbred, they do produce a pink and white variety—although not overnight, as the Tudor legend would have us believe.

Yet another Welsh writer attributes the emblem to a custom called *Cymhortha*, where neighbours congregate to celebrate the harvest, each taking a leek for the dinner broth. Since the farmers carried the leeks to the celebration in their hatbands, they were adopted as the Welsh badge.

However, the daffodil is also considered to be a Welsh emblem. The reasons for its selection are not well-chronicled but, apart from aesthetic reasons, it may be attributable to the daffodil's Welsh name of *Ceninpeder*, meaning leek of St Peter, which links it with the leek itself.

Three-fold symbol Although the Irish emblem is the shamrock, it is not known for certain exactly which species of plant this is. Wood sorrel, black medick, white clover and lesser yellow trefoil have all been put forward by different authorities as likely candidates. All have the important feature of a leaf comprised of three leaflets, but the flowers vary from the white petals with lilac veins of the wood sorrel, to the tighter flower heads of the other three species, which all belong to the pea family.

Most of the legends associate the shamrock with St Patrick. He used the shamrock as an illustration of the Trinity of the Christian church. Picking a shamrock leaf, he would explain that the Father, Son and Holy Ghost were united, just as the three leaflets of the shamrock grew from one stalk.

Above: The four different species that have all, at various times, been acclaimed as the Irish emblem, the shamrock, because of their three-fold leaves.

Right: The daffodil may have been chosen as an alternative Welsh emblem because of its attractive appearance. Wild daffodils (*Narcissus pseudonarcissus*) can be found in flower in meadows and damp woods from March to April.

A symbol of remembrance

Each scarlet flower of the familiar field poppy (*Papaver rhoeas*) lasts just one day, although a single plant can produce about 400 flowers from May to October. This is thought to be the species that grew around the battlefields of Flanders during the First World War and was immortalised by Colonel John McRae in the poem he sent to *Punch* magazine in 1915. He begins,

'In Flanders' fields the poppies blow
Between the crosses, row on row . . .'

Artificial poppies are sold in the weeks before Remembrance Sunday to raise money for ex-Servicemen and their families.

LEOPARD AND GOAT MOTHS

The caterpillars of the goat and leopard moths – insects widespread in this country – are notorious for the damage they cause to trees.

Above: When resting on a tree trunk in daylight, the goat moth may easily be mistaken for a broken piece of bark. The pale grey-brown wings, clouded with white (particularly the forewings) and marked by innumerable transverse wavy black lines, give the moth excellent camouflage. The female is much larger than the male, often having a wingspan twice the length of his.

The goat and leopard moths are the most commonly encountered of the three British species belonging to the Cossidae, a primitive family of moths. The large goat moth, with pale grey-brown colouring, is the commonest of the two, occurring in most parts of the British Isles, though it is only really numerous in southern England. It is found both in rural and urban districts, provided there are sufficient numbers of old trees to nourish its wood-eating caterpillars.

The leopard moth's strongholds are also in the south of England, particularly in the south-east; it becomes rarer as one progresses northwards and is absent from the northernmost counties, Scotland, Ireland and much of Wales. Also known as the wood leopard moth, it has a particular liking for old timber in built-up areas, and is more easily spotted than the goat moth with its white wings and thorax covered in blackish blotches.

The third member of the Cossidae is the reed leopard moth (*Phragmataecia castaneae*), a species found only rarely in this country, and then largely confined to the fens of Cambridgeshire and Norfolk.

Harmful caterpillars One of the most interesting and accurate accounts of the goat moth's life history was published as early as 1766 by the famous 18th century English entomologist, Moses Harris. He described how the female deposits her oval, dirty-brown eggs in a confused heap on the bark of a tree. She may choose to lay them on a wide variety of trees, but willows, ash, elms, oaks and poplars are favoured. Although living trees are usually selected, caterpillars are sometimes discovered feeding in damp decaying wood.

The caterpillars hatch a week to a fortnight after the eggs are laid, and immediately begin to feed on the tree bark. They bore into the bark, reaching the wood beneath by the end of their first year of development. Thereafter they burrow into the heartwood of the tree, in due course forming tunnels as large as a man's thumb.

Because of the low nutritional content of wood they remain caterpillars for a long time. On the Continent they may complete their development in two years, but in this country they usually take three or even four years to obtain enough starch and sugar to pupate. By this time they have developed thick bodies up to 10cm (4in) in length. The goat moth caterpillars are flesh coloured, with a dark reddish-brown back; the small head is jet black and shiny, and equipped with powerful mandibles for chewing wood.

Groups of trees are often infested by more than one goat moth's offspring. The trees may be so riddled by the tunnels of the large caterpillars, which can bore their way from the top to the bottom of the trunk, that they are utterly destroyed. The goat moth can therefore be a real pest, although serious depreda-

Below: **Goat moth** (*Cossus cossus*)
Wingspan: female 9–10cm (4in), male 7cm (2¾in).

Above: **Leopard moth** (*Zeuzera pyrina*)
Wingspan: female 6cm (2½in), male 3.5–4.5cm (1½–2in).

Opposite right: A glance at the leopard moth readily explains its English name: the white semi-transparent wings and fluffy white thorax, spotted with bluish black, are reminiscent of a leopard's coat. The yellowish orange veins on the wings are also a distinctive feature. Although both sexes are remarkably long, the male is noticeably smaller than the female, whose body ends in the long ovipositor that is necessary for inserting the eggs deep into bark crevices.

tions in orchards are rare.

Chrysalis stage In September, when fully fed, the goat moth caterpillars can be seen wandering along the ground in search of suitable pupation sites. They either burrow into the soil, and spend the winter resting there, or crawl to within 12cm (5in) of the entrance to tree-tunnels and there gnaw away at the wood, carving large chambers. Here the caterpillars overwinter in strong cocoons made of their own silk and chips of gnawed wood. They eventually pupate the following spring, either in the soil or in their chambers, forming a plump glossy chestnut chrysalis, cylindrical in shape and about 4cm (1¾in) long.

In June or July the fat-bodied goat moth is ready to emerge. While still in the pupal case, it pushes itself through the weakest part of the cocoon towards the entrance of the tunnel, where it immediately breaks out of the case. During the daytime the moth rests inconspicuously on tree trunks or fence posts, but at night it takes to the wing, often being seen in houses where it is attracted by bright lights.

Orchard pest The life-cycle of the leopard moth is similar in several respects to that of the goat moth. The female leopard moth is considerably larger than the male, and lays her glossy brown eggs in untidy rows in bark crevices. The caterpillars hatch in late summer and instantly start feeding on the wood. This makes the tree foliage wither, causing considerable damage, particularly in orchards where the moths favour apple and pear trees.

In Britain, leopard moth caterpillars take two to three years to mature, tunnelling through the wood all the time. They are stout-bodied and dull yellowish in colour, with numerous black shiny spots from which black hairs protrude. When fully fed, which is usually in May or June, each caterpillar builds a cocoon of chewed wood and silk near the entrance of its tunnel. When this is complete it becomes a chestnut brown pupa within the cocoon.

On emerging in July or August, the moth forces itself, still within the pupa, to the tunnel entrance, before breaking out of its case and climbing up the bark outside, where it eventually comes to rest, expanding and drying out its spotted wings.

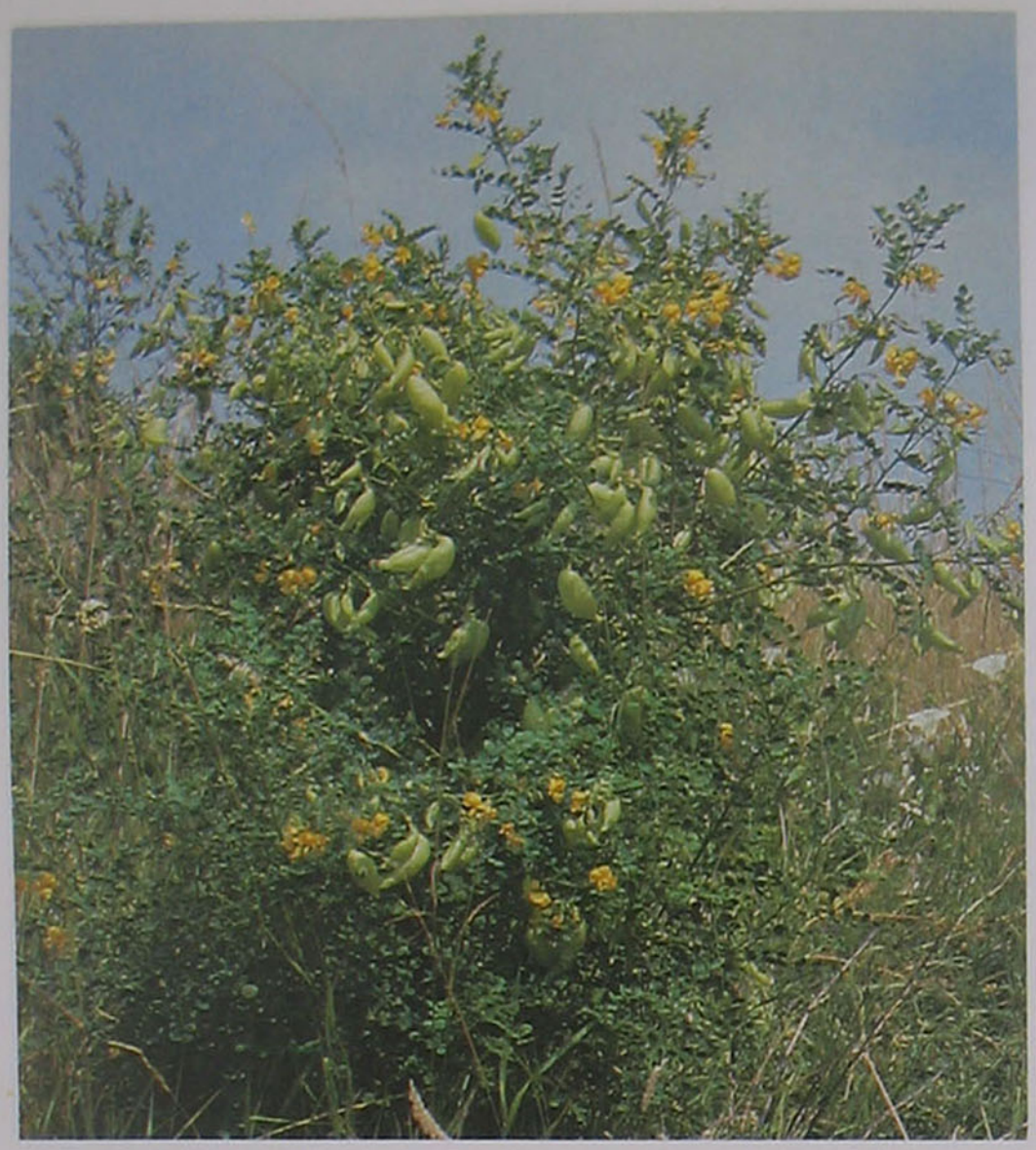
Leopard moths may appear on the wing as early as June and are found as late as September. They fly at night, often being attracted to electric lights in houses, but are most easily found in the early morning, when they have just emerged from the pupal case. They are quite often seen on the branches of those trees known to be infested with their caterpillars.

When resting motionless in the daytime they are extremely reluctant to fly, even when provoked. The females are especially unwilling to take wing in daylight, rather suffering themselves to be pecked to pieces by any birds which happen to find them.

Tree-tunnelling caterpillar

The female leopard moth lays her glossy brown eggs in crevices or cracks in bark. When the caterpillars (right) hatch from the eggs in late summer or early autumn they begin to eat their way through the bark and into the wood. They are normally found in branches (the goat moth caterpillar prefers tree trunks), where they can cause serious damage. On the Continent leopard moth caterpillars are regarded as pests of gardens and orchards, but in Britain they are less of a problem—alder, birch, horse chestnut, oak, sycamore and apple are among the trees they infest.

Left: The caterpillar of the goat moth betrays its presence by ejecting wood chippings and sawdust from its burrow entrance, this detritus accumulating at the base of the tree. It also has a repugnant smell that emanates from a yellowish oil secreted by glands in its head. It is said to resemble the smell of a male goat, hence the moth's name. When a group of trees has been infested by these caterpillars, they can be smelt from a considerable distance.



BLADDER SENNA: POPPING PODS

Introduced from the Continent 400 years ago for its medical properties, the bladder senna now grows wild in Britain, particularly on waste land. Its strange pods, which explode when squeezed, provide a source of great delight for children.

Above: Although not native to Britain, the bladder senna flourishes here and has become naturalised, particularly in southern England, where it is often found growing on rubbish tips, railway embankments and other waste ground. Indeed, it will grow almost anywhere, provided there is enough light and the soil is not too waterlogged. This specimen was found on an area of waste ground in East London, less than 6km (4 miles) from the Tower of London.

Bladder senna is a vigorous deciduous shrub native to central and southern Europe, its range extending from France to Greece and Turkey, though it is absent from the Iberian peninsula. It has only fairly recently become naturalised in some northern European countries, including Britain, where it is most common in the southern counties of England.

The earliest record of a bladder senna being grown in Britain is in 1568. At the end of the following century the travel writer and horticulturist Celia Fiennes wrote approvingly of it as 'a fine tree that bears a great branch of yellow flowers' and, in 1778, the horticulturist John Abercrombie described it as 'elegant furniture for the shrubbery'.

Today, it is naturalised in Britain, favouring rubbish tips, railway embankments (especially in London) and other waste ground. Bladder senna can tolerate the poorest of soils and is capable of growing almost anywhere, provided there is enough light and the soil is not waterlogged. Indeed, it is one of the very few plants to be found growing on the crater of Mount Vesuvius in Italy. More typical sites for it on the Continent are dry slopes and open woods, preferably ones with a limey soil.

Senna look-alike The bladder senna was probably first introduced to Britain for its medical qualities. It was regarded as a useful purgative and was commonly grown for that purpose, though its effect seems not always to have been to the patient's benefit.

The medical reputation of this plant was, however, based in part on confusion between it and various species of the true senna, which were used medicinally but are quite a different group of plants. The problem of wrong identification was recognised early for, in the late 16th century, the herbalist John Gerard warned his readers 'that they are deceived that thinks it [the bladder senna] to be Sene, or any kinde thereof; although we have followed others in giving it the name Bastard Sene, which name is very improper to it'. But, in spite of Gerard's wisdom, the confusion was to remain for many years.

Nowadays, botanists classify the bladder senna in a different genus (*Colutea*) from that of the true sennas, which all belong to the genus *Cassia*. Both genera, however, belong to the pea family, bear seeds in pods and have yellow flowers – hence the original confusion. But, while the flowers of the bladder senna are typically pea-shaped, those of true sennas are much less so.

Brittle branches Bladder senna is a quick-growing shrub, usually growing no more than 5m (16ft) high. It has a bushy habit and its branches, which are covered with grey flaking bark and prominent white lenticels, are brittle and easily snapped off, in a high wind for instance. The effects of such damage to bladder senna probably gave rise to the mistaken belief that the plant dies if its branches are lopped. Its Latin name, which comes from the Greek 'kulouo', meaning to amputate, also reflects this idea.

As an interesting sideline on the plant's name, Theophrastus, a Greek philosopher and botanist of the 3rd century BC, referred to a plant which he called 'koloutea', but whether this was the bladder senna we do not know.

The leaves are 8-15cm (3-6in) long and borne alternately on the shoots. Each leaf is compound, consisting of between seven and thirteen soft green leaflets arranged pinnate fashion. The leaflets are about 6mm-2cm ($\frac{1}{4}$-$\frac{3}{4}$in) long and broadly egg-shaped with a notch in their tips. They are hairy beneath when young but lose most of the hairs by the

time they mature.

In June and July, clusters of golden-yellow flowers are borne in the leaf-axils of the current year's growth, more appearing as the branches extend. The clusters are 4-10cm ($1\frac{1}{2}$-4in) long and carry three to seven flowers.

Each flower is about 2cm ($\frac{3}{4}$in) long and has four petals arranged in typical pea-fashion. At the bottom is the keel; slightly above and to the sides are a pair of wing petals, which are slightly shorter than the keel; at the top of the flower is the standard petal, which is large and occasionally has faint red markings on its inside surface towards the centre. The calyx, which encloses the flower when it is in bud, is cup-shaped, green and covered with black and white hairs.

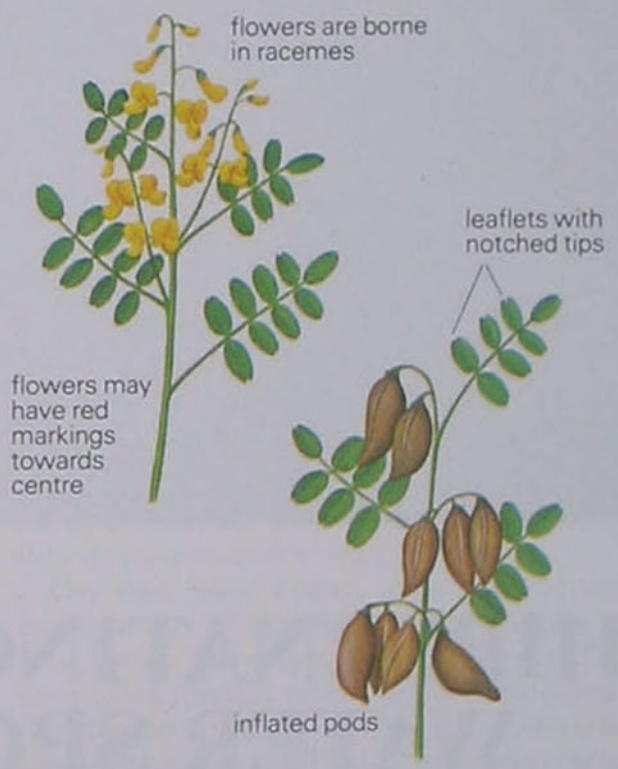
Exploding pods As with all plants in the pea family, the bladder senna bears its seeds in pods. In this species, the pods are about 4-7cm ($1\frac{1}{2}$-$2\frac{1}{2}$in) long, pointed and green with reddish tinges, especially at the ends. Each pod contains between 15 and 20 seeds.

A curious feature of the pods is that they are inflated and burst with a loud noise when squeezed, which makes them particularly attractive to children. Henry Philips, who in 1825 wrote a book called the 'Language of Flowers' in which he assigned qualities to different plants, made the bladder senna stand for 'Frivolous Amusement'. He commented that 'children find amusement in dancing on, or pressing these little bladders'.

Above: Young pods of bladder senna, photographed in June. The reddish tinges on the pods are common on this species.

Left: The flowers are bright yellow and typically pea-like, with a large standard petal (sometimes with red markings, as here), smaller wing petals to the sides and the keel beneath.

Right: **Bladder senna** (*Colutea arborescens*). Introduced deciduous shrub native to southern and central Europe. Height to 5m (16ft).



Below: Despite the ripe pods on this bush, a few flowers are still appearing and will continue to do so until the autumn.

HIBERNATING FRESH WATER SPONGES

Not all British sponges are to be found in the sea. A few encrust stones and weeds in fresh water where, as an adaptation to the less stable conditions inland, they have developed a form of hibernation that protects them from the extremes of winter.

Above: A specimen with such long finger-like projections is more likely to be a pond sponge (as it is here) than a river sponge. This rule is by no means infallible, however, for the shape of a sponge is determined to a great extent by environmental factors. The green patches are caused by the presence of a symbiotic alga, *Chlorella*, living in the sponge's tissue. The dull brown of the rest of the sponge is its normal colour.

Of the 5000 or so species of sponges in the world, almost all are marine. Worldwide there are only about 150 freshwater species, and of these just five are found in the British Isles.

There are two common British species of freshwater sponges – the pond sponge (*Euspongilla lacustris*) and the river sponge (*Ephydatia fluviatilis*). The former is usually found as an encrustation, often with finger-like projections, on stones, sticks and weeds in fairly still water, whereas the latter tends not to have such long projections and is found on the undersides of stones and timber, both in the water and on river banks. The pond sponge tends to occur in stiller, deeper water than the river sponge, though both species are tolerant of a wide range of environments and neither is confined to the habitat that their names suggest. They may both be found in conditions ranging from fast-flowing water to the stagnancy of a marshy pool, and even occur in brackish water.

Structure and feeding In their structure and feeding habits, freshwater sponges closely resemble their marine counterparts. Their bodies consist of a body wall with a number of minute openings that lead into canals extending throughout the sponge. These canals are lined with collar cells bearing tiny flagellae that beat in unison to draw a current of water into the sponge. The current carries food and oxygen to the sponge, and then leaves via large pores called oscula, carrying away with it the sponge's waste products.

In the simpler marine sponges the canals lead into a large central cavity, but freshwater sponges all have complex body walls that are heavily folded to obliterate this cavity.

In both the pond and the river sponge the shape of an individual depends on the strength of the current flowing past it. Sponges lying in still water tend to have more projections and their oscula are often situated on small 'chimneys'. Both of these features help to ensure that waste products are ejected well away from the sponge. On the other hand, individuals lying in strong currents tend to be flattened.

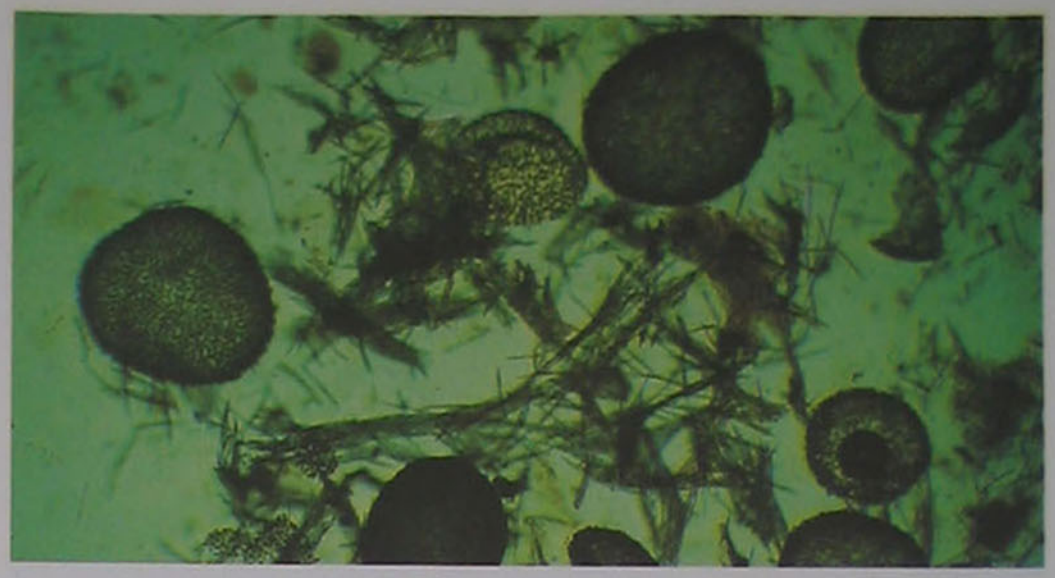
The colour of both species of freshwater

sponges is variable, being usually a dull yellowish-brown, though they are often green due to the presence of a unicellular alga called *Chlorella* living in their tissues. Parts of the sponge hidden from the light are much less green than the exposed parts because few algae (which need light for photosynthesis) grow there.

Pond or river sponge? With their variable colour and shape, distinguishing the two species is extremely difficult. The only sure method is to examine the spicules under a microscope. (The spicules can be obtained by leaving a fragment of the sponge in domestic bleach overnight. The soft tissues dissolve away to leave the spicules, which can then be examined.) The spicules are made of silica and help to strengthen the sponge's body wall. In the river sponge they are all smooth, spindle-shaped and slightly curved. Most spicules in the pond sponge are similar but scattered among them are some slender spiny spicules about a quarter of the length of the others.

On the Continent, the spicules used to be dried and ground into a powder. This was used in a variety of ways. By being rubbed on the affected area, it was supposed to cure rheumatism–it may, indeed, have had some relieving effect: the irritation of the spicules probably produced a local warmth over the area which helped to alleviate the pain. The powder was also used as a cure for black eyes and, in Russia, girls applied it to their cheeks as a form of rouge. At the end of the last century, the powder was sold in Britain, under the name 'Russian fleas', to children who used it as itching powder.

Ways of reproduction Freshwater sponges can reproduce in several different ways, all but one of which they share with the marine species. They reproduce asexually by budding, a technique in which a small bud forms on the surface of the sponge, grows and breaks off to become a new individual. They also reproduce sexually, generally during the summer. As with the marine sponges, fertilisation occurs in the water canals and the larva escapes through one of the oscula. After a planktonic free-swimming stage, the larva settles down in a suitable habitat and develops into a new sponge.



Above: Gemmules of the river sponge. They may be seen as tiny brown spots within the sponge or scattered over stones in a stream or pond. As well as acting as an over-wintering stage, the gemmules also help to distribute the sponge, for they are sufficiently small to be dispersed over great distances by wind or birds, as well as by water currents.
The tiny rod-shaped structures in the picture are the sponge's spicules.

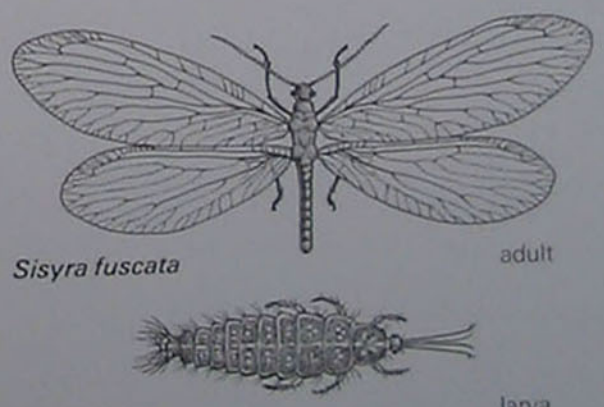
Below: Just as marine sponges are host to a wide variety of sea creatures, so the freshwater species are often similarly associated with other animals. The best-known example is the sponge fly, whose larvae feed on sponges. There are three species of sponge fly in Britain, of which the most common is *Sisyra fuscata*; all resemble rather dull-coloured brown lacewings and have a wingspan of 11-14mm (about $\frac{1}{2}$in).

However, freshwater sponges have one method of reproduction not shared by the marine sponges. To cope with the fact that their environment is much less stable than the sea, freshwater species produce over-wintering reproductive stages called gemmules. These form in the autumn when some of the sponge's cells aggregate and develop a hard covering, strengthened with spicules, so that it is highly resistant to extremes of temperature, humidity and other environmental factors. As winter arrives and the temperature drops, the sponge itself disintegrates, but the gemmules survive and, with the return of more favourable conditions in the spring, they develop into new sponges.

One-time pest Today, most people are hardly aware of the existence of sponges in their ponds and rivers, but in the past they were often forcibly reminded of these primitive creatures. They were once a considerable nuisance because of their tendency to grow in water pipes, often giving the drinking water a bad taste. Water pipes provide a highly favourable habitat for sponges, since there is a regular–but not too fast–flow of water through them. With the establishment of sponges within the pipes, whole communities of animals feeding on them would move in as well, sometimes causing severe pollution to the drinking water supply.

Life-cycle of a sponge fly

All three species of sponge fly have a similar life-cycle. In May and June the female lays her eggs in small clusters on vegetation overhanging water, covering each batch with a silk web. After two weeks the larvae emerge and drop into the water. They swim around jerkily in search of a sponge and, on finding one, settle on its surface or within its water canals. There they feed on the sponge, using their long straight mouthparts equipped with curved tips to pierce the sponge's tissues.
In the autumn, the larvae leave the water and hibernate in silk cocoons attached to tree trunks or bridges.
In the following spring they pupate and emerge as adults for the cycle to begin all over again. Both the river and the pond sponges can be host to the larvae.



A WOODLAND, CAVE AND FELL WALK

The plateau of Ingleborough, at an imposing height of 723m (2373ft), is the dominating feature of a cluster of virtually treeless fells in an area of north-west Yorkshire known as Craven – the setting for the largest outcrop of limestone in Britain.

Ingleborough is composed of Great Scar limestone, lying on Silurian rock and supporting the alternating bands of shale, sandstone and limestone known as the Yoredale Series. The summit of Ingleborough, a 6-hectare (15-acre) plateau, is composed of millstone grit. Many walkers start their ascent at Ingleton, or the Hill Inn at Chapel-le-dale to the north-west. Our walk, however, takes a longer, more gradual route from the village of Clapham.

The village There is a National Park Information Centre (with adjacent car park) at Clapham during the tourist season. The village itself is sited at the mouth of a small valley known as Clapdale, and occupies what was once the bed of a glacial lake. It is divided

into two by a beck which has its main feeder stream high on Ingleborough. Fell Beck, as it is known in its upper reaches, tumbles 104m (340ft) into the main chamber of the pothole known as Gaping Gill, re-emerging from the mouth of a cave at the head of Clapdale.

At Clapham, stand on the single-arch footbridge (known locally as T'Brokken Bridge) and look around. There may be a dipper bobbing on the stones within yards of the bridge, and if you are fortunate you may see it enter the clear water and swim or walk against the current. The trees nearby were planted in the last century by the Farrers of Ingleborough House (now a field centre), and they are mainly decorative. A profusion of trees–cherry, whitebeam, sycamore, beech and chestnut–keeps much of the beck in shade.

Above: Small 'trips' of dotterel–a member of the plover family–have been reported occasionally from high on Ingleborough, passing to or from their more northerly nesting grounds.

Left: The distinctive shape of Ingleborough's 6-hectare (15-acre) plateau looming in the distance; this view is taken from Ribble Head. Climbing Ingleborough is a popular occupation. Each year two races–one for runners, one for cyclists–include the summit as part of a 40-km (25-mile) circuit which also takes in both of Ingleborough's two prominent neighbours, Penyghent and Whernside, each standing over 610m (2000ft) high. The existence in this area of a honeycomb of potholes and caves, including Ingleborough Cave and the renowned–and vast–Gaping Gill, is a testimony to the erosive quality of water which collects a weak solution of acid from the atmosphere and the soil and gradually wears down the soft limestone.

The Farrer family is of special interest. The name of Reginald Farrer (1880-1920) is revered by rock gardeners who follow his ideas on how alpine plants should be displayed. In 1970, the 50th anniversary of his death, the Reginald Farrer Trail was established at Clapham. Our walk follows the first part of this Trail on the ascent of Ingleborough.

The lake The lake and the impressive waterfall at the head of Clapham Village were created when the Farrers dammed Clapdale in the 1830s. The water is some 12m (40ft) deep near the limestone crags you can see on the eastern side. These crags were planted with alpines by young Reginald Farrer.

There is little bird life on the lake, which tends to be cold and gloomy, hemmed in as it is by crags and trees. Trout, most of them on the small side, and a considerable number of eels, have been found.

The woods The lake has a woodland setting. The woods are entered (on payment of a small fee) at the cottage in the sawmill yard at the head of Clapham. Early last century larch, spruce, pine and oak were among the species planted here. Beech and sycamore, which do well on limestone, are still there today, together with pines and spruces. Some Norway spruce, planted by the beck beyond the lake, have yielded 27m (90ft) of clean timber per tree–demonstrating the effect of general

shade in 'drawing up' growing trees. The woods are well-managed, mature timber being felled and new trees planted immediately.

Represented in the area today are some sitka spruce, the common species of modern coniferous forests. Look out for single trees with commemorative plaques, especially some just off the main track, near the head of the lake. Here and there are some Weymouth pines and red oaks – distinctly unusual species for this part of Britain. The indigenous trees include holly and yew.

Where the woods are open, with little ground vegetation, woodcocks may nest. Anyone walking here on a spring evening may see a 'roding' woodcock – a plump bird flying steadily at about 15m (50ft) from the ground, at intervals uttering a call which has been described as 'three grunts and a squeak'. This evening flighting takes place around the bird's territory; if you wait a while, it may return as part of another circuit.

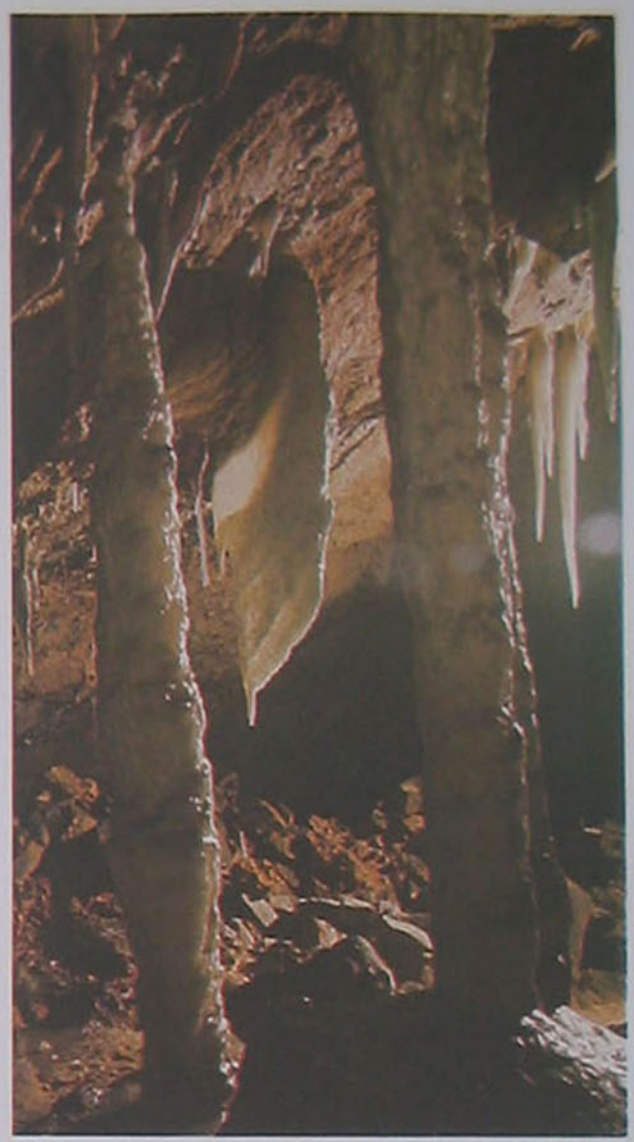
The North Craven Fault crosses Clapdale at the head of the lake. As you walk along the broad path you will find yourself looking down into a steep-sided valley where, instead of the familiar pearly white limestone, there is a darker, older rock, and with it a soil that has a high acid content. This pocket of Ordovician rock explains why, in what appears to be a limestone country, there is a healthy growth of acid-loving Himalayan bamboos and rhododendrons. They were planted by Reginald Farrer.

Ingleborough Cave When you leave the woods, notice the effect a wall has in a district which has been, for at least 1000 years, a grazing area for sheep. The wall has a restraining effect on livestock: behind you is a luxuriant growth, before you a valley where bare limestone has reappeared to view, with fine, low-growing ground vegetation. The trees on the hillsides are mainly old hawthorns.

Ingleborough Cave, which is open to public view at prescribed times, can be explored in safety and comfort. The visitor takes a path between limestone formations created over many years by the steady drip of lime-laden

Above: Visit the Reginald Farrer Trail in autumn and you may well witness the full glory of the sycamore trees in their full fall-of-the-year colours. Sycamore does well on limestone, as, too, does the beech – another tree to look for on the Trail.

Below: Members of the tit family, especially the coal tit, can be both seen and heard along the woodland Trail. The white patch on the nape of the coal tit's neck distinguishes it from marsh and willow tits.



water. Those that hang are stalactites, those growing from the floor are stalagmites. Sometimes the two grow together, forming a pillar. There are also curtain-like formations on the sides of the cave. At one point the cave roof falls to well under 1.5m (5ft), so be prepared to bend–or even crawl.

Trow Gill After a short walk up a dry valley, its sides bearing a litter of limestone boulders–many covered with mosses and lichens–you arrive at what is generally said to be a collapsed cave. Trow Gill narrows between high limestone cliffs until you have to walk with considerable care up a boulder slope to gain the open moor.

Trees grow along the rims of the Gill. Not far away is Rayside, an elevated wood on the 400m (1300ft) contour line, representing woodland very nearly at the limits of its economic growth. On the windward side are some Scots pines; the rest of the wood is a mixture of larch, ash and sycamore.

Gaping Gill A prominent path leads from Trow Gill to Gaping Gill. The limestone nature of the countryside is everywhere evident–in the walls, the outcrops, and the potholes (open limestone shafts). When you reach Gaping Gill, do not venture too near the edge. You will see a funnel-shaped depression extending to a rim of limestone. The hole into which the stream pours is 104m (340ft) deep. In fact, by the time the water reaches the pebbly floor, it is hissing like steam in a chamber that is one of the largest in Britain. The water that flows from Gaping Gill reappears in a cave near Ingleborough Cave. Here a pair of dippers has nested for years, making their domed, mossy nest at roof height.

Pothole clubs are usually here during the Spring and August Bank Holidays. The first man to descend Gaping Gill–and return to tell the tale–was a Frenchman, E A Martel, who descended by rope ladder in 1895. When Meets are held nowadays, a petrol-driven winch and bosun's chair are used. As the visitor descends, he or she feels like a spider dangling under the roof of a cathedral!

The open fell The usual way of ascending Ingleborough from this direction is by a path

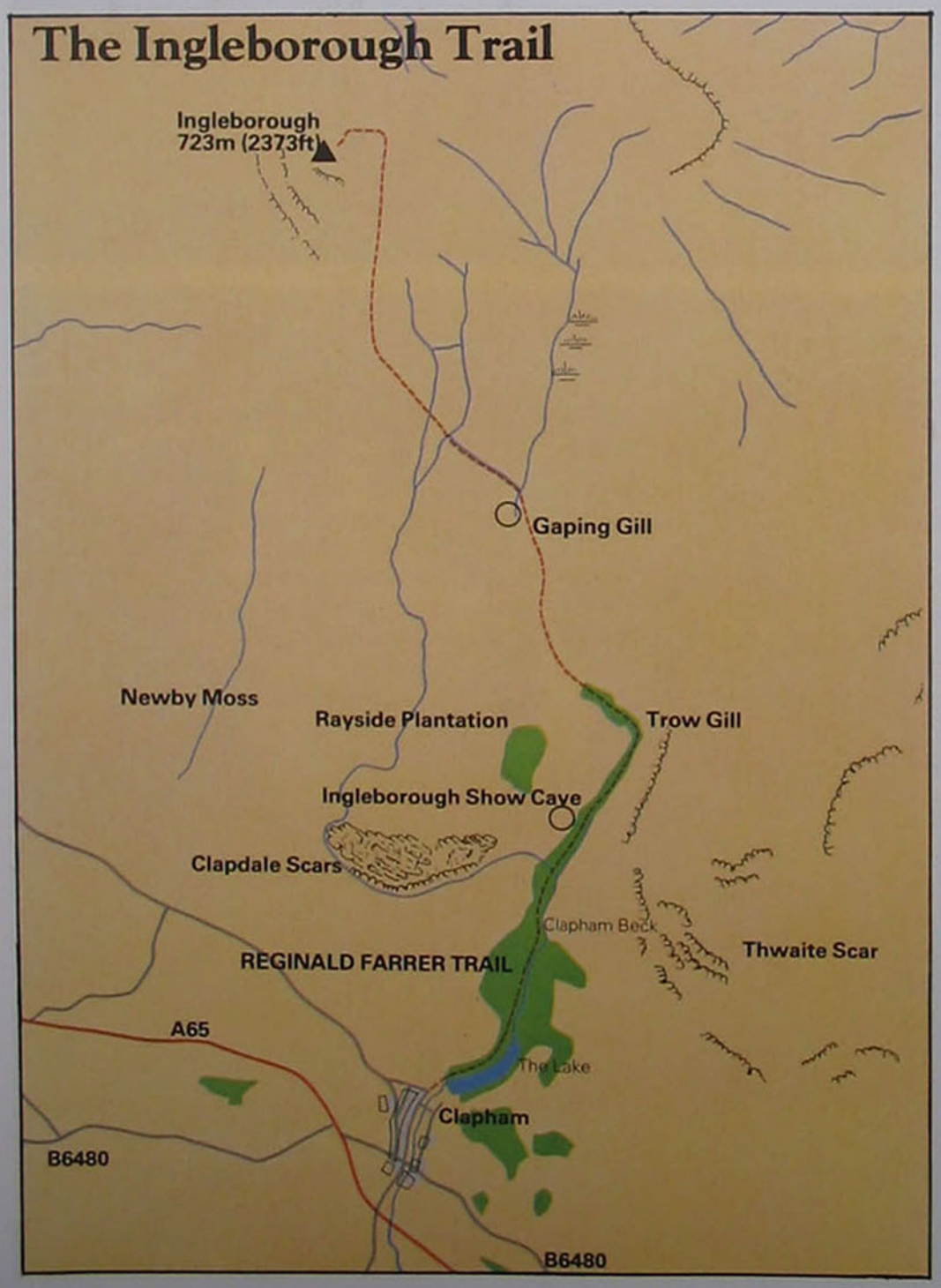
Above: The none-too-large entrance to Ingleborough Cave. This cave was made accessible by the Farrers and their workmen who, in 1837, broke through an ancient stalagmitic barrier and released the water of an underground lake.

Right: One of the many magnificent formations of stalactites/stalagmites to be seen within Gaping Gill.

Below: Cottongrass–a species common on the open fells of Ingleborough.

Left: Hart's tongue fern growing within the safety of a grike (crevice) on Ingleborough's limestone pavement.

Below: The route of our walk—the climb up Trow Gill to the summit of Ingleborough is steep, so wear suitable walking shoes. To reach Clapham, take the Pennine bus service on the Skipton-Ingleton route, or a BR train to Clapton Station (1½ miles from the village); or, by car, take the Keighley-Kendal road (the A65 at Clapham, which has been by-passed). There is parking space available at the Information Centre.



that leads first to Little Ingleborough, then dips and climbs again to the major plateau. The walker crosses the open fell. If a tree is seen, it is more than likely that it is growing from a pothole–rooted far enough down to be able to develop without being nibbled by sheep.

The Dales-bred and Swaledale sheep have been largely responsible for the disappearance of what was once an extensive heather moor, the heather being found mainly on the drier ridges, with sphagnum and cottongrass (it is actually a sedge) in the moist areas that are known as mosses. Little heather remains. Much of the present landscape is covered with a tussocky grass, *Nardus stricta*.

Bird life is not profuse. Very few birds are seen in winter, when the only sound may be the honk of a carrion crow, or the gruff bark of a raven. Birds from the nesting areas on the northern Pennines tend to move southwards to the Craven area for the winter. In early spring, the waders return.

There is the golden plover–known as the Pennine whistler–uttering its sad call from the highest ground. Lower down, the bubbling trill of a curlew can be heard, or you may hear the yelping alarm of an individual curlew whose nest is close by. During the past half century the curlew has become a common nesting species in the foothills and upper and middle reaches of the Dales. The redshank is another bird of the uplands.

The commonest nesting species is probably the meadow pipit, but plenty of skylarks can also be heard and, in the steep-sided narrow gills, some of which extend far up the fells, the ring ouzel, a close relative of the blackbird, may be observed.

Most of the interesting plants of the area occur on the Yoredale Series. They include the purple saxifrage, one of the first species to flower, in late March or April.

On the summit This is a bleak, windy place, with gritstone outcrops and peaty areas. There is a shelter, and also a view indicator, erected by the Ingleton Fell Rescue Team.

The views are outstanding, taking in the Cumbrian Fells, the Howgill Fells and, clearly, Pendle Hill to the south-west. In this direction, when viewing conditions are crystal clear, the green form of Snaefell on the Isle of Man can be seen, while the eye ranges over Morecambe Bay to the west. Penyghent and Whernside are close by, and between Ingleborough and the latter fell is Chapel-le-dale, hewn out into its present shape by glacial action.

Publications You can obtain a leaflet on the Reginald Farrer Trail from the Information Centre at Clapham. Dalesman publications (established at Clapham over 40 years ago) include the magazine *The Dalesman*, *Around Ingleton and Clapham*, five volumes of *Northern Caves* and *Walking in the Craven Dales*. Write to The Dalesman, Clapham, via Lancaster for a further book list.

TIMBER AND ITS PRODUCTS

Timber is the most valuable of all our natural resources. From fuel and building materials to tools, furniture and paper, we use timber for so many different purposes that it is almost impossible to imagine life without it.

Below: Logs of beech after felling. Along with oak, beech is the most commonly used hardwood in Europe. Its combination of strength and lightness makes it ideal for furniture and a range of domestic products, such as handles and spoons.

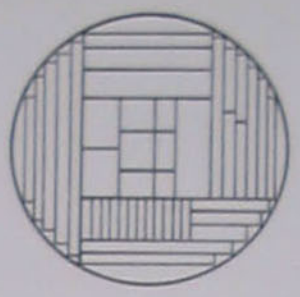
Although all parts of a tree have their uses, commercially its most important part by far is its wood. Of all the timber felled in the world, about half is used for fuel in the form of logs or charcoal, much of it in the tropics and the Third World countries. The rest is used as timber or processed wood – plywood, chipboard and pulp.

A quick look at the wooden items found in a house soon shows that wood is not a uniform material but extremely variable, differing in pattern, colour and hardness. The most basic difference is between the wood of conifers, such as pines and cedars, which is called 'softwood', and that of the flowering trees (beech, oak and so forth), which is called 'hardwood'. However, these terms are confusing since they refer only in the most general way to the strength and durability of the two groups. For example, the softest, lightest wood is the 'hardwood' balsa, along with certain true 'softwoods', such as spruce.

Wood structure When looked at in cross-section, a tree trunk contains several different layers. On the outside is the protective bark; inside is the food-conducting phloem; inside that is a thin layer of cambium where the trunk forms new cells; then comes the water-conducting wood, the xylem, and in the centre is dead xylem, the heartwood.

For timber, the most important parts of a tree are the xylem and the heartwood. The xylem contains several types of cell, occurring

Cutting a log



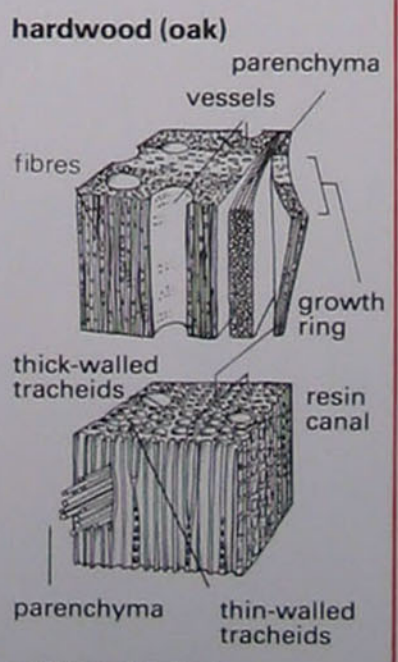
Above: There are many ways of sawing up a log. In this method, called 'round the log', each of the four sides is worked in turn to give a variety of planks, and the centre is then cut up for structural timber.

Left: A plantation of Douglas firs in the Forest of Dean. This wood is much used for building.

Below: Piles of peeled conifer logs ready for pulping in the Alice Holt Forest, Hampshire.

Structure and growth rings

The xylem of a hardwood contains vessels to conduct water and minerals, fibres to provide support and parenchyma to store food. In some species, such as oak, the vessels formed in the spring are larger, making the wood paler than at other times of the year—hence the appearance of annual growth rings. Other hardwoods, such as beech, show no such differences in their cells through the year. However, they do lay down different materials into the wood during the summer, so growth rings are still recognisable.
Softwoods also possess parenchyma, but the function of the vessels and fibres is combined in the tracheids, which perform a combined conducting and supporting role. Softwoods also show growth rings because the tracheids laid down in the summer have a smaller diameter and thicker walls than those produced in the spring.



in varying amounts in different species of tree. The differences between hardwoods and softwoods are due to the fact that they contain different types of cells.

In hardwoods, the most important component is the vessels, which consist of tubular cells placed end to end to act as a passage for minerals and water. Surrounding these in most hardwoods are fibre cells—long, thin, tapered cells with extremely thick walls, which provide the vessels with a supporting matrix. The variation in hardness between the different hardwoods is due mainly to the properties of these two groups of cells. In balsa, for example, the fibre cells have thin walls and the vessels are large and closely spaced. On the other hand, ebony, which is one of the hardest and heaviest woods, has thick-walled fibre cells with small, widely spaced vessels, which are often made harder by extremely tough deposits of gum in the middle of the cells.

Most species of hardwood trees have a third component called wood parenchyma. These are thin-walled cells that store food materials. They are arranged in vertical stacks that radiate from the centre of the wood outwards in lines known as medullary rays. These are responsible for the characteristic grain patterns of certain polished woods.

Softwoods have a quite different structure. They lack separate vessels and fibres, instead having tracheid cells that perform a combined conducting and supporting role. They also have parenchyma. Both sets of cells have channels to allow resin to flow.

Heart of the matter The cells in the xylem have a limited life span. Over a period of years their walls become impregnated with a substance called lignin, which makes them become gradually harder and rigid. Eventually, the cells become blocked with lignin, die and become a part of the tree's heartwood. Since the cells retain the same shape in death as they had in life, the structure of the heartwood is the same as that of the xylem.

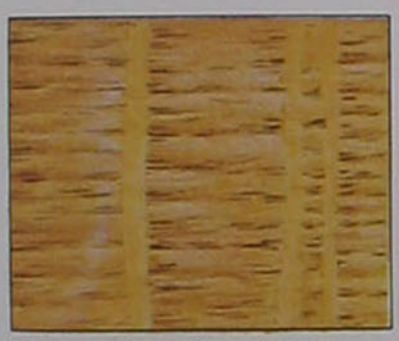
There are considerable differences in colour and hardiness between the heartwood and the xylem due to the presence, in varying degrees, of gums and resins produced in the cells. In the most prized timbers, such as ebony, the heartwood is almost black from the presence of hard resins and gums, which also make this wood extremely hardy.

Timber for building The different uses to which timber may be put are determined by its characteristics—its grain pattern, density, colour, hardiness and so on. For example, balsa is ideal for making model aeroplanes because of its lightness, whereas heavy woods teak, ebony and box—are more suitable for furniture-making. Cedar wood is often used for the outside of houses because of its attractive appearance and resistance to rot. Elm is useful for lock gates and the bottoms of barges because it does not rot easily under water, while the lightness and toughness of beech

Commercial woods

Beech is white or pale brown with a straight grain and characteristic flecks.

Ash is white and straight-grained with conspicuous growth rings.



Oak is pale yellow-brown and straight-grained with a coarse texture.

Olive is pale to medium brown with dark markings and an irregular grain.

Cedar is a pale brown wood with a strong characteristic fragrance.

makes it a good choice for the roofing frames of houses.

However, before any wood can be used in building or furniture manufacture it has to be dried in controlled conditions. Fresh wood contains water (which is why logs crackle in a fire) and, as it dries, it shrinks, warps and cracks. Obviously, this cannot be allowed to happen to wood that has been incorporated into a building or a piece of furniture, so it is dried out before being used. This used to be done by leaving the logs or cut planks out in the open, but nowadays they are seasoned in humidity-controlled kilns to produce a large quantity of workable timber in the fastest possible time.

Processed wood The last 20 years or so have seen marked changes in the pattern of timber use. The value of timber has increased so much that the appearance of an end product is now often more important than the materials that go into its manufacture. A familiar example is chipboard which, when coated with a plastic laminate, is used for kitchen work surfaces and utility units in the home.

The advantage of chipboard is that it can be made from all sorts of wood, particularly trees too small to be cut into planks, and it can be made to any size and be manufactured by machines.

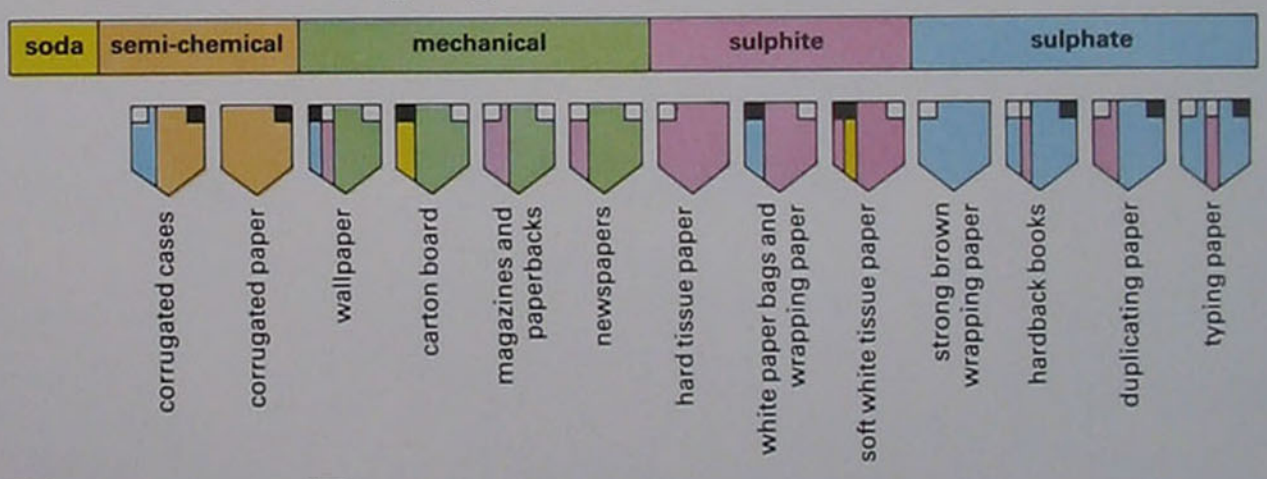
Plywood is a combination material of a different sort. Thin sheets of wood are glued together with the grain of each layer lying at right-angles to the grains of the layers immediately above and below. The 'ply number' – such as 3-ply or 6-ply – refers to the number of sheets. Plywood is much stronger than a plank of wood of the same thickness and the arrangement of its sheets makes it resistant to warping.

Timber for pulping Today, vast quantities of wood are pulped for paper. To give just one example, a top-selling national newspaper will consume up to 15,000 trees in a single edition.

Wood pulp is produced either mechanically or chemically. In the former process sections of logs are gradually pulped on a revolving grindstone and the fibres removed by water. In chemical pulping, the logs are chipped into pieces and then digested in either soda, calcium or magnesium sulphate or sodium sulphite. The resulting slurry is then beaten and chopped in a huge cylinder equipped with a rotating set of knives. China clay or starch is added to fill in pores in the wood fibres and give weight to the paper, and dyes and resins are added to reduce absorbency.

The mixture is then pumped into a paper-rolling machine, where it is passed through a series of rollers that squeeze the pulp into paper. Finally, after being dried, the paper is passed through chilled rollers to give it a finish. Fine-quality papers may be glazed with China clay or some other material to give them a glossy finish.

Products from pulp



Above: The chart shows the different treatments given to pulped woods to achieve different products. For example, carton board is mainly produced mechanically out of softwood, although a proportion is manufactured from soda-treated hardwood. Half of all the softwood timber cultivated in the northern hemisphere goes for pulping.

Left: A pulp mill in the Highland Region, with piles of timber cut into chips ready for processing.

HARRIERS : A THREATENED TRIO

Harriers are large, broad-winged birds of prey. In Britain only three species occur–the hen, marsh and Montagu's harriers–out of a world total of about nine or ten; and all three are now rare and very restricted in their distribution here.

The shape, size and silhouette of harriers are all distinctive and unlikely to cause confusion with other birds of prey. They are broad-winged, slender-bodied birds with long narrow tails. When seen in flight they are very distinctive, flying buoyantly and gracefully, usually low over the ground, with dexterous turns and changes of direction as they quarter for food or make a half-pass at likely prey.

As with most other birds of prey, female harriers are noticeably larger than the males, in this case by some 5cm (2in) or so. They are also less brightly coloured.

When three apparently similar species occur in the same area, there is usually a clear ecological separation between them, often in their use of different types of habitat. This is amply demonstrated by the three British harriers. The hen harrier is a moorland specialist, and the marsh harrier a reed bed and marshland bird, while Montagu's harrier –a rare summer migrant– has a strong preference for lowland heaths and arable fields. This latter species is a little more catholic in its choice of habitat than the other two although, being confined in Britain to land below 76m (250ft) or so, it no longer overlaps with the hen harrier.

Distinguishing our harriers There are few more exciting sights for bird-watchers in Britain than a dove-grey male hen harrier sweeping buoyantly over the dark, rolling expanses of a heather moor. The males are uniformly pale grey above, relieved only by broad black wing tips and a white band at the base of the tail. At a distance the males can appear so pale that they often resemble a large gull. The females are much darker, being brown birds with a white rump patch that stands out clearly. Hen harriers are confined to heather moors.

Above: A female hen harrier drops down to her nest with prey for the young.

Right: A fluffy young hen harrier; both females and immature birds have banded tails and are often referred to collectively–and evasively–as 'ringtails'.

Opposite page: The head of a harrier is distinctive in shape, appearing strikingly owl-like from the front, with marked facial discs and a very small decurved bill. All species show a distinct neck ruff, in particular the hen harrier, as can be seen here.

Below: A female hen harrier at the nest. On their own territory some birds can be very aggressive, making spectacular diving attacks on intruders.

It was only in 1802 that a Colonel Montagu, studying harriers in Devon, realised that the smaller birds he saw were an entirely separate species from the hen harrier. Montagu's harrier, named after the Colonel, is a summer visitor which formerly bred, albeit sparingly, across the southern half of England and Wales but is now extremely rare.

In appearance and hunting methods it closely resembles the slightly larger hen harrier, but males can be distinguished by the narrow black centre lines on the wing and by the absence of a white rump patch. Balanced and delicate on the wing, Montagu's harrier flies even more lightly than the hen harrier, and its wings are distinctly longer and narrower. The female Montagu's harrier is very similar to the female hen harrier, the two being considerably more difficult to tell apart than the males of the species.

In former times, when great areas of reed bed covered the fenlands of East Anglia and other parts of the country, the marsh harrier was a familiar and widespread bird. Marsh

Identifying harriers

Marsh harrier (*Circus aeruginosus*). Very rare summer visitor to parts of East Anglia. Largest harrier at 48-56cm (19-22in).

Montagu's harrier (*Circus pygargus*). Very rare summer visitor to Devon, Cornwall and Norfolk. Smallest harrier at 41-46cm (16-18in).

Hen harrier (*Circus cyaneus*). Resident in northern heather moors or lower ground in winter. Length 43-51cm (17-20in).

The 'food pass'

Hen harriers use a special 'food pass' in mid-flight, the female snatching the food from the male in a turning roll as he drops it.

Above: The distribution of our three harrier species. After a disastrous decline in the 19th and early 20th centuries these birds have shown a small rise in numbers since World War II.

harriers are the largest of the family, distinctly heavier-looking and broader-winged than the others and consequently less buoyant and manoeuvrable in flight. Both sexes are predominantly brown, the male showing grey only on the tail and parts of the wings; the female is a dark-plumaged bird with a prominent creamy head and creamy shoulder patches.

Changing fortunes Our large birds of prey have been persecuted over the last hundred years or so in a systematic and comprehensive way. Harriers were no exception, and all three of our species fell victim to the ruthless control of predators in the name of game preservation in the 19th and early 20th centuries. The gun and the trap have thus been responsible for the wholesale removal of some of our finest birds of prey. Following this, the reclamation of heathland, fen and moorland for intensive farming has drastically reduced the available breeding areas suitable for these species.

In the early years of the 19th century the hen harrier was a widespread breeding bird in tracts of wild heathland from the Orkneys to the south coast counties of England. In some areas it was extremely plentiful, and accounts of local carnage testify both to the number of birds and the ruthlessness of the killing; on two Ayrshire estates, for instance, 351 hen harriers are claimed to have been killed between June 1850 and November 1854. By the onset of the First World War the hen harrier was extinct as a breeding bird everywhere except the Orkney Islands.

Only after the end of World War II, when keepers had been away for several years, was it evident that a slight resurgence was taking place. The steady spread has continued, and there are now perhaps 600 pairs on moorland in Scotland, Ireland, northern England and north Wales. The bird is still illegally persecuted, however, especially by people with grouse interests, because the hen harrier definitely takes young grouse, but more so because of the effect a hunting harrier has on grouse–forcing them into concealment and

thus conflicting with an expensive sport on shooting days.

The marsh harrier has fared little better. It was extinct in Ireland by 1917, by which time it had also temporarily disappeared from England and Wales. The end of World War II again marked a period of modest revival, centred on East Anglia, and by 1958 twelve to fourteen pairs were nesting. Although numbers have fluctuated since, they have remained of this order, with the best-known pairs being those breeding at the RSPB's Minsmere reserve in Suffolk.

There is little doubt that Montagu's harrier was always a scarce bird in Britain, being at the northern edge of its range here, although it, too, fell victim to gamekeepers and egg collectors in the 19th century, and has since suffered from destruction of its habitat. Nowadays it has the most tenuous of toe-holds here each summer, the beautiful dove-grey form of the male being a rare and sporadic sight over the rough commons and heathlands of Devon, Cornwall and Norfolk.

'Dancing' in the sky As the harriers start to re-occupy their breeding territories in spring they also begin to display. The courtship flights of all three harrier species are dramatic and exciting. The male marsh harrier performs high soaring flights above the chosen nesting place, followed by remarkable aerial evolutions, plunging with half-closed wings, steepling high again, tilting, tumbling and looping in an ecstatic flight reminiscent of the wild gyrations of the lapwing. Montagu's and hen harriers, closely related and similar in many ways, also have spectacular diving displays. The males rise to 30m (100ft) or more and then, twisting sideways or somersaulting, plunge headlong earthwards, checking abruptly just above the ground and swinging up again to repeat the process.

Above: A male Montagu's harrier and (below) a male marsh harrier. Throughout most of their European ranges these two species, and the hen harrier, have been in almost constant decline. Montagu's harrier is, without a doubt, one of the rarest and most threatened birds of prey in Europe, and the hen harrier and marsh harrier have patchy distributions with centres of population interspersed with areas that are now intensively developed and unsuitable for breeding.

At about this time, when the nest site is chosen, the male begins to feed the female, continuing to do so as she incubates the eggs for the four and a half week period. The male now carries out all the hunting, making use of a spectacular technique to pass food to his mate. As he approaches with prey in his lowered talons, the female rises from the nest to meet him. When she reaches him, flying slightly below, she rolls to her side or right over on her back, extending one long slender leg to snatch the food as he drops it, then rights herself so swiftly that the movement is often difficult to follow.

Growing up and feeding After hatching, the young birds stay close to the vicinity of the nest for five weeks, up to the time they fledge, being tended by the female first with food provided by the male but later on with items provided by both parents.

Harriers hunt in a low coursing flight, quartering the ground slowly and methodically, striking at their prey with dexterous turns and making full use of the long reach of their slender legs. Hen harriers prey mostly on voles and other small mammals, together with the chicks of such wading birds as lapwings and golden plovers, and on young grouse and other moorland birds. Montagu's harriers take a higher proportion of lizards, large insects and small birds, while marsh harriers prey on small amphibians and reptiles and a wide range of marshland bird nestlings, as well as on water voles and other small mammals.

By winter Montagu's harrier has moved far south to tropical Africa; many of the marsh harriers, too, move to southern France or the Iberian peninsula. Only the hen harrier – the most northerly of all the harrier species – winters here.

WANDERING WASPS

Above: A male large velvet ant (*Mutilla europea*), feeding on yellow mountain saxifrage. This species is not really an ant but a wasp. Part of the name comes from the female (below) whose hairy coat is said to resemble velvet. In colour and size both sexes are similar, but only the male has wings. Their striking colour pattern may be an example of warning coloration since the female's sting is particularly painful.

Not all wasps make their own nests; some species, such as velvet 'ants' and ruby-tailed wasps, parasitise the nests of bees, or even lay their eggs on the larvae of other insects.

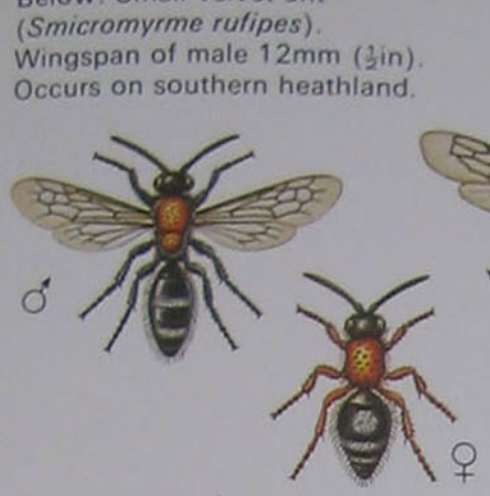
The females of most wasps catch their prey and store it in specially constructed cells as provisions for their young, or feed it directly to them in nests. There are, however, a few groups of wasps which do not do this. These are the 'wandering wasps', which either seek out a host on which to lay an egg or else lay their eggs in the nests of bees and other wasps and act as parasitoids (parasites which kill their hosts).

These homeless wasps are thought of as a link between the nest-constructing wasps and the fully parasitoid ichneumon wasps which actually lay their eggs inside the host victim. Most wandering wasps are found in warm countries, but a few species occur in Britain.

'Bee-wolves' The large velvet ant–not an ant at all but a wasp–is a colourful British species belonging to the family Mutillidae. A parasitoid of bumble bees, it is usually about 12mm (½in) long, the actual size depending on the dimensions of the larva which it fed on. This wasp is strikingly marked, having a black head, legs and antennae, a red thorax (the front of which is black) and a bluish-black abdomen with yellow or white bands.

Large velvet ants are not very common, but the females can sometimes be found running along warm banks in both England and Scotland where they seek out and enter the nests of bumble bees. Once inside the nest, the female stings the fully grown bee larvae or pupae and then lays an egg on each one within its cocoon. The velvet ant larva hatches after a few days and consumes the bee larva or pupa in about two weeks. It then spins its own cocoon within that of the bee and completes its transformation. The adult velvet ant emerges in a further two weeks.

Below: Small velvet ant (*Smicromyrme rufipes*). Wingspan of male 12mm (½in). Occurs on southern heathland.



Above: *Tiphia femorata*. Wingspan of male 13mm (½in), female 22mm (⅞in). Found on umbellifers near S coast.

Below: *Methoca ichneumonoides*. Wingspan of male 15mm (⅝in). Widespread where tiger beetles are found.

Male velvet ants leave the bumble bee nests fairly quickly. They may be seen at flowers or flying low over the ground following a zig-zag course, in search of females.

Although seen more frequently than their mates, the females stay for up to two weeks in the bumble bee nests, taking long drinks from the honey 'pots' before they depart to mate and start the cycle again.

The females are thought to overwinter in the hosts' nests, presumably after they have been fertilised, although exact information is not available. Male wasps appear as early as May, with numbers building up in late summer–this supports the view that there are probably at least two generations of large velvet ants born a year.

Although female velvet ants are parasitoids of bumble bees, they have been found to enter honey bee hives in Europe, where they kill the adults by biting their necks to extract honey and body fluids. Their depredations can be so severe, with as many as 200 bees killed in a single hive in one day, that they are known as 'bee-wolves'. In Britain they are never common enough to cause such damage.

The small velvet ant, a parasitoid of ground-nesting solitary bees and wasps, is similar to the larger species in colour and pattern, but differs in detail–the band at the base of the abdomen resembles a spot, while the other bands are more complete. Like its relative, the female is wingless but the rarer male is winged.

Beetle biter Frequently found on umbellifers (the parsley family) near the coast in southern England, *Tiphia femorata* is a black wasp with partly red legs. The female's legs are particularly strong since they are used to tunnel into the ground in search of chafer and dung beetle larvae. When one is found, the wasp stings and then kneads the victim, using its mandibles. This may increase the paralysis induced by the sting or else provide the female with food high in protein. She then lays an egg and cements it firmly to the lower side of the host larva, which usually recovers after an hour or two, and is apparently able to continue feeding. On hatching the parasitoid perforates the skin of the chafer grub and gradually consumes it from the outside.

Tiger beetle feast Related to *Tiphia femorata* is another wandering wasp, *Methoca ichneumonoides*, whose larvae feed on tiger beetle grubs. Various species of *Methoca* occur all over the world, coinciding with the distribution of tiger beetles on heathland.

The male is larger, but rarer, than the female. The female is quite common though often mistaken for an ant. She searches for the tiger beetle's fierce larva in its burrow, and then either stings it directly under the neck to paralyse it, or else allows herself to be caught before delivering her paralysing sting. Sometimes there is quite a fight before the tiger beetle larva is pacified. The parasitoid then retreats and waits outside for the sting to take full effect, before re-entering the burrow, stinging several times more, then kneading the victim with her mandibles and finally laying an egg. She fills in the burrow with soil, leaving her own larva to hatch after two days and feed on the tiger beetle grub.

The young *Methoca ichneumonoides* larva punctures the skin of its host and feeds for about a week, but owing to the great size of the tiger beetle larva it may not be completely consumed.

When fully fed *Methoca ichneumonoides* and *Tiphia femorata* larvae spin their own cocoons and overwinter within them. Still in the host's burrow, both these species pupate in spring, and emerge as adults in summer.

Above: *Chrysis ignita* is the most common of several species of ruby-tailed wasps. Usually seen flying around walls and fences in warm weather, it has a metallic red abdomen, and greenish-blue head and thorax. It has lost the ability to sting and rolls up into a ball when threatened, its hard armour protecting it from the stings of other bees and wasps. The female lays her eggs in the nests of solitary bees and wasps. She can be seen inspecting cracks and holes in walls. If these are occupied by bee or wasp cells she slips inside and lays her own eggs there. These hatch in under a week –if more than one has been laid the first larva to hatch consumes the rest. The *C. ignita* larva waits in the hole for the rightful owner to become fully grown and then feeds on it until fully grown itself. The plump larva then spins a cocoon to overwinter in, pupates in spring and emerges as an adult in June.

MUNTJAC: SMALL DEER

Introduced from southern China during the last century, the muntjac deer – a very small species – has been spreading gradually throughout the countryside of England.

Above: A Chinese muntjac buck. This species is sometimes known as the barking deer because of its hoarse bovine cough which is uttered every four or five seconds.

The Chinese muntjac deer, a native of southern China and Taiwan, was first brought to London Zoo in 1840. It was introduced to the grounds of Woburn Abbey by the Duke of Bedford in about 1900 and since then it has spread from the Abbey's evergreen shrubbery into nearby woodlands and out into the surrounding countryside. Since then it has established itself as far north as Nottinghamshire, to the Home Counties, out into the Welsh Marches, Sussex and, rather thinly, to parts of East Anglia.

The muntjac is a small deer with a characteristic rounded back. The buck is considerably heavier in the neck and shoulders than the doe. The body colour is bright chestnut in summer but rather duller in winter, the big bucks being particularly dark in winter. The upper surface of the tail and back of the thighs is bright ginger in both summer and winter. The white undersurface of the tail is usually visible only in flight or fright, when it is raised, showing a bright white flash. When a muntjac is angry or aggressive the chestnut tail and the hair on the back of the legs can be fluffed up; in extreme aggression the whole of the body hair stands up, making the animal seem larger.

Simple antlers Only the bucks have antlers; at about 7cm (2¾in) long they are short in relation to the animal's body size when compared with those of other deer; they are also deciduous, falling off in May and June. The antlers are carried on bony, hairy projections (pedicles) of the frontal bone. The bony pedicles start to grow when the muntjac is four months old and take about three months to mature; the straight, backward-pointing antlers are grown from May to September, and you may see animals with pedicles but no antlers (the pedicles looking, nevertheless, like antlers) all the year round. An animal born in January starts to grow pedicles in April or May, but they are not fully formed until August – too late for the antlers to develop. The pedicles remain in velvet, or with tiny button cap antlers, throughout the following winter.

Below: Muntjac deer are very small compared with other deer species found in Britain. Their closest relative is the Indian muntjac, found in India and other parts of Asia.

Female muntjac bear dark haired marks in place of antlers. They have a dark crown patch and less well-defined facial markings than the males. In both sexes the face is lighter than the body colour, being yellow, or occasionally a shade of orange.

The most interesting feature of muntjac bucks is their protruding canine teeth. These are just visible, projecting from the upper jaw as small tusks, and are thought to be used for defence and fighting purposes. Does also possess canine teeth, but these are much smaller and less apparent.

Bramble habitat The favoured habitat of the muntjac is bramble thicket, usually where it has grown in newly planted woodland among young trees, or on wasteland or even in gardens. Motorway banks, factory grounds

and Ministry of Defence restricted areas are also favoured.

Although muntjacs are shy animals, they benefit from their association with man. Not only do they feed in gardens but in severe weather they take shelter in garden sheds and outhouses, thus maintaining their populations. In Forestry Commission stands where there has been no shelter in hard winters some muntjac have died.

Family animals Although muntjac are described as solitary, they do in fact have a family structure. A buck and a doe will remain within the same area for a period of years. Fidelity is difficult to prove, but the impression is of pairs mated for life, although with the death or injury of a partner a replacement mate (presumably solitary up until now) is taken within a matter of days.

Territories are marked by scent secreted from glands on the head and below the eyes, and on the pelvis and hind feet. Urine and faeces are also used as territorial markers– the droppings, which are sometimes left individually but can collect gradually in latrines, are small, shiny, cylindrical black pellets pointed at one end and depressed at the other. The deer often use their teeth to strip the outer bark and tissues of plants and shoots and then they anoint the bared wood with a secretion from the head glands.

If bucks are disturbed on their marked territory they fight with their canines and antlers only as a last resort. Does behave aggressively towards other does, but relatives, particularly their own grown-up fawns, are tolerated. The muntjac registers aggression by raising itself as high as it can on its four legs; its hair stands out and the animal presents itself side-on to produce a silhouette of maximum size. An animal wanting to show minimal aggression, or even submission, lies with its feet tucked in and its chin on the ground.

Continuous breeding The does normally breed continuously. They are sexually mature at seven months old and drop a single fawn after a pregnancy of 210 days. Within two or three days of the doe giving birth the buck is actively chasing her again, and copulation is repeated many times. If conception is not achieved, oestrus appears to occur once a week on average.

Fawns are relatively large at birth and weigh about 1kg (just over 2lb). They can walk immediately and run within two or three days. For the first six to eight weeks their coats are spotted but the pattern becomes gradually obscured as a fluffy juvenile coat grows through the baby coat. They are milk-fed during the first two months, although they start to graze at a few days old. The fawns have a characteristic cry–a penetrating squeak uttered regularly that can be heard from over 100 yards away. Lactating does call their young with a curious yelping sound.

As an introduced species, muntjac fit well into our countryside. They are more widely distributed in a given area than roe deer, and do far less damage. They can become a nuisance in gardens, however, unless fenced out. Such trespassing may attract the attentions of 'sportsmen', and many deer carry gunshot wounds or other injuries. An injured or trapped deer has a penetrating cry.

It is seldom necessary to control muntjac as their dispersal mechanism ensures against a build-up of a population in a single area. The first muntjac to arrive in a new area are usually bucks, for it seems that bucks leave home earlier and travel a greater distance than does. Muntjac are often heard before they are seen: their bark is distinctive; they also squeak when sexually stimulated.

Above: A muntjac doe and her fawn in Hertfordshire, an area that is well populated with this species. They graze on most green plants and even those that are poisonous to other animals, such as yew. The picture on the left shows a buck muntjac.

MUNTJAC DEER
(*Muntiacus reevesi*)
Size of adult Male about 48cm (19in); weighs 13.5kg (30lb). Female 45cm (18in), weighs 11.7kg (26lb).
Breeding season All year.
Gestation period 210 days.
No of young One.
Lifespan 15 years.
Food Bramble, ivy, yew, dog's mercury, bluebells, garden plants, grasses, food from bird tables, fruits.
Predators Man, cats, dogs.
Distribution See map below.

Muntjac distribution

MANY MOSSES

Mosses grow in a wide range of habitats–from coast to mountain top–and they have evolved a rich diversity of forms to suit their very varied lifestyles.

Above: The leafy stems of *Hookeria lucens*, a species of very damp soil or rock, form delicate, shiny patches on the substrate.

Below: The distinctive spore capsules of *Tortula muralis* appear in spring and summer. The tiny leaves have long hair-points protruding from their blunt tips and it is thought that, collectively, these hair-points may act as a heat-reflective barrier over the moss cushion, helping to prevent water loss.

Many factors affect the nature of moss communities. Apart from geographical location, some significant environmental influences include the availability of water, the intensity of the sunlight, temperature levels, the degree of pollution, and the nature and permanence of the substrate.

Many mosses are endohydric; they possess internal water conducting tissues efficient enough to draw water into their leafy shoots directly from the substrate. An even larger variety of mosses are ectohydric. These are able to absorb water over their whole surface and may lack efficient internal water conducting tissues.

Stone-dwelling species Several ectohydric species are adapted to survive the rather exposed conditions encountered on rocks and walls.

Andreaea rupestre is a common inhabitant of acidic, siliceous rocks in the mountainous regions of north and west Britain. Its short reddish-brown or black shoots grow in compact tufts. Packed together in this way the leafy stems are less vulnerable to buffeting winds and are also less subject to water loss by evaporation. The narrowly triangular leaves, composed of small, rounded cells with very thick walls, overlap and press closely to the stem when drying out. These features of leaf structure and arrangement all help to reduce the rate at which moisture is lost.

A species thriving in cool mountain and lowland areas, *Racomitrium lanuginosum* possesses creeping, much-branched stems which form patches or tufts on exposed and normally acidic rock and soil.

The leaves of *R. lanuginosum* are lance-shaped and often curved to one side with long, fine white tips or hair-points. Unlike those of *Andreaea*, the leaf cells are long and narrow with thick, wavy longitudinal walls and relatively thin cross walls. This kind of cell may act like a living capillary tube in drawing water along the leaf.

Another colonist of acidic rocks is a species restricted to maritime areas–*Schistidium maritimum*. Its short, erect stems bear stiff, lance-shaped leaves and grow in blackish-green cushions. This species is highly tolerant of salt water and will survive periodic bombardment by sea spray. For most other mosses, exposure to sea spray proves fatal.

Tortula muralis is another cushion-forming moss with erect stems. It frequently grows in urban areas on basic (alkaline) walls where it is often conspicuous because of its clusters of narrowly cylindrical spore producing capsules on long red stalks known as setae. Knob-like projections on the leaf cells called papillae aid the conduction of water over the leaf surface. When the plant is in danger of drying out, the tongue-shaped leaves trap moisture by winding spirally around the stem.

Soil-dwelling species Of special interest among the soil-dwellers are the ephemeral

mosses which may colonize regularly disturbed substrates such as the soil of arable fields. Owing to their environment, they have a characteristically rapid life-cycle.

Bryum rubens is an ephemeral species. To increase the odds of survival on a temporary substrate, the thread-like, branching outgrowths called rhizoids, which anchor the plant in the soil, develop 'moss tubers'. Viewed with a microscope, these tubers appear as bright red, knobbly balls. They can survive for several months while lying dormant in the soil, and contain stored nutrients in the form of oil globules. When conditions are favourable, these are used in the growth of new shoots.

Below: Common on rotting wood, *Aulacomnium androgynum* produces spore capsules only rarely. It relies instead on vegetative reproduction in the form of gemmae, which are produced in clusters at the tips of long stalks. Each yellowish gemma is egg-shaped and attached to the 'head' by a short stalk.

Shoots of the endohydric *Bryum rubens* have leaves composed of large, lax, thin-walled cells and lack many of the water-controlling adaptations evolved by the rock-dwellers described above.

A few species of moss are unable to survive away from almost permanently wet habitats. *Hookeria lucens*, for example, is restricted to damp, well-shaded soil or wet rocks. The creeping branches bear broad, round-ended leaves composed of large, lax, thin-walled cells which are visible to the naked eye.

Wood-dwelling species A characteristic tuft-forming moss of rotting tree-stumps, *Aulacomnium androgynum* has green, erect shoots with small, broadly lance-shaped leaves. It seldom produces spores, but compensates for this apparent lack of sexual reproductive power by producing gemmae. These have the same function as rhizoidal tubers in ephemeral mosses. However, unlike tubers, the gemmae of *A. androgynum* are produced in spherical masses at the tips of long stalks known as pseudopodia.

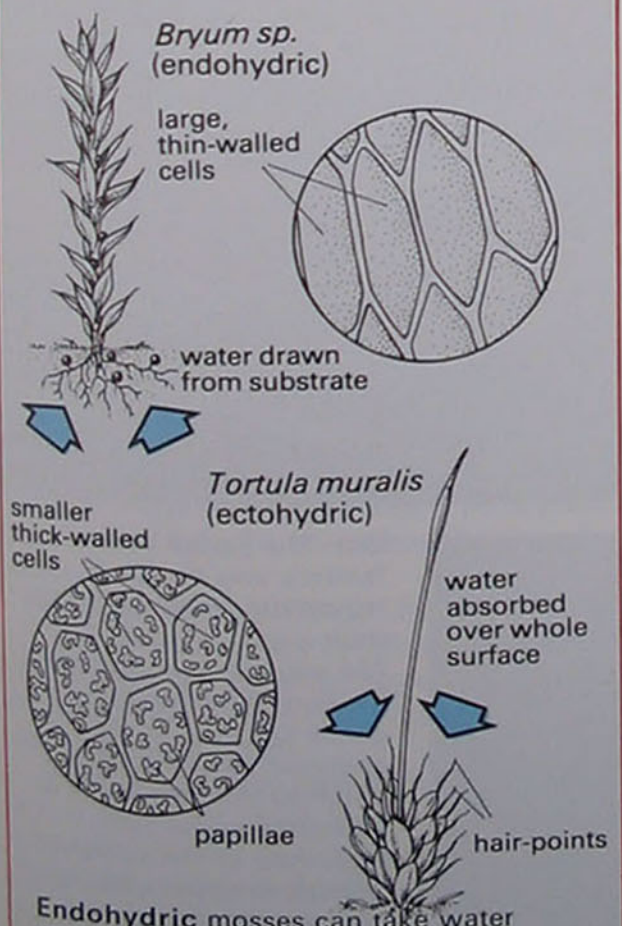
Many species belonging to the genus *Orthotrichum* produce gemmae at the tips, or on the surfaces, of their leaves. Nearly all of these species also produce spores.

Orthotrichum diaphanum, for instance, forms neat tufts on trees and wooden fences. Immersed among the hair-pointed leaves are spore capsules borne on very short setae. These are conspicuous before maturity owing to their bell-shaped caps (calyptrae) which have a fuzz of short, white hairs around their pointed tops.

Unusual environments Some mosses require very different conditions from those described above. *Fontinalis antipyretica*, for example, leads an aquatic existence in still or flowing fresh water. Attached to rock or wood, the long, branched stems with three rows of boat-shaped leaves grow in long, straggling tufts.

Yet other mosses inhabit even more unusual substrates. Sheep and cattle droppings on high moors and heathland provide habitats for species of *Splachnum*, while rocks rich in copper – and toxic to most plants – form the ideal substrate for the species *Mielichhoferia elongata*.

Moss forms



Endohydric mosses can take water directly from the substrate. Their leaves may have a thin waxy cuticle to reduce water loss. **Ectohydric** mosses can absorb water over their whole surface.

Below: The greyish-green *Racomitrium lanuginosum* dominates the mountain vegetation known as 'racomitrium heath'. This moss grows in cool conditions on acidic rock and peat at high altitudes where competition from flowering plants is minimal. One of the larger species of British mosses, it has individual branching stems growing up to 15cm (6in) long.

TROUT FARMS AND HATCHERIES

The trout on sale in your local fishmonger's are almost certainly not taken from the wild. Instead, they will have been bred in carefully controlled conditions, starting as eggs in a hatchery and then being reared on a trout farm.

Below: A typical trout farm with its ponds and tanks containing fishes at different stages of development. Estimates vary, but there are thought to be around 500 trout farms in Great Britain.

Trout farming has become big business in Britain. There are now about 500 trout farms throughout the country, each year rearing between them more than 5000 tons of trout – which is about 15 million fishes – for food and for stocking waters. And the figure is increasing year by year. For example, the annual tonnage in 1981 was 5200 tons, whereas the year before the figure was 4400 tons. Yet we are still a long way behind some Continental countries such as France and Denmark, which reared 21,000 and 18,000 tons of trout respectively in 1981.

The most common species of trout farmed in Britain is the rainbow trout, a fish native to North America and introduced here in the 1880s. The next most popular is our own native brown trout. The only other species farmed, though on a much smaller scale, is the American brook trout, also known as the brook charr.

Methods of farming There are many different methods of farming trout, though the principle is much the same in all cases. This is to have a constant flow of water passing through a series of tanks or pools containing the fishes and on to an outlet so that the fishes' waste products are washed away. The method used varies from an extensive system of large pools to an intensive system where the whole operation is carried out indoors in environ-

Left: The typical trout farmer's year begins in November when the mature trout are ready to spawn. The eggs are stripped out of the female by firm but gentle pressure on the abdomen (far left). Milt is obtained from the males by a similar process (left). Each drop of milt contains millions of sperm cells, so only a small amount is needed to fertilise a large volume of eggs. The eggs and milt are mixed together, allowed to stand and then washed clean.

mentally controlled tanks. However, all three different species are farmed in the same way, despite the rainbow trout's migratory background.

Most old trout farms run by Water Authorities or sporting estates are based on the Danish earth pond system, so-called because it originated in Denmark. Water flows through a series of ponds, each anything from 100sq m (1000sq ft) to 800sq m (8000sq ft) in area, and is then discharged into a watercourse. The water may be supplied by building a dam across a stream, with a dyke to carry the water to the ponds; or the farm may be fed with spring water, or with water from a borehole. A disadvantage of the first two systems is the possibility of silting during flooding and of pollution from upstream. On the other hand, borehole water also presents problems because of the possibility of gases coming out of solution because of the drop in pressure when the water is brought to the surface.

A more recent design is to have water flowing through concrete troughs. This greatly reduces the build-up of waste products and so allows more trout to be grown. The other general type is the Swedish tank design, in which water is directed at an angle into a circular tank, so that there is a continuous circular flow of water inside. Water with the fishes' waste products is continually removed, usually at the centre, and the whole system keeps the tank extremely clean. The tanks are usually made of concrete, fibre glass, steel or aluminium.

Above: The eggs develop very slowly—rainbow trout eggs (shown here) take 30 days at 10°C (50°F) to hatch into fry and those of brown trout take 41 days to hatch at the same temperature.

Above: When they hatch the young fry bear large yolk-sacs and lie on their sides. Gradually they struggle upright.

Below: Once upright the fry are fed on solid food and grow into young trout.

Trout hatcheries Trout farms normally stock only fishes about 10-15cm (4-6in) long—called fingerling trout—or larger. They do not breed the fishes; instead, this is done in a special trout hatchery.

There are as many different types of hatchery as there are trout farms, but again the principle is much the same. Spawning takes place in November—the female is held by her tail and, if she is ready to spawn, creases appear on each side of her abdomen. The eggs are stripped out into a bowl by gentle but firm pressure on the abdomen. Milt (sperm) is then added by stripping the males in a similar fashion. The eggs and milt are mixed together, allowed to stand and then washed clean. They are then placed in a trough in a steady stream of water and allowed to hatch. While the eggs are developing (and they can take at least a month to hatch) they have to be inspected each day and the dead ones removed to prevent infection of the others.

Rearing the fry When they hatch, the fry bear large yolk-sacs and grow lying on their sides. Gradually, they struggle upright and swim up through the water, at which stage they are called 'swim-up' fry. (In the wild this stage is when the fry work their way up through the gravel in which they hatch to the water to start feeding.) They must then be introduced to solid food, usually a diet based on fish protein.

The conditions in which the fry grow have to be carefully controlled, particularly the concentrations of oxygen and carbon dioxide in the water. The temperature of the water is another important factor. In general, it is best to keep the temperature to around 9-11°C (48-52°F).

As they grow, the fishes have to be sorted into sizes. Even in the most favourable conditions, trout grow unevenly and it is only a matter of time before the largest fishes become three times the size of the smallest ones. Once that happens, the inevitable result is cannibalism, which can quickly gather its own momentum.

Regional trout production

Shown below are the tonnages of trout raised per annum in each of the Regional Water Authorities. These figures cover only the largest of our trout farms, but the trend is clear.

		1974 (tons)	1975 (tons)	1976 (tons)
1	North West	10.0	71.0	103.0
2	Northumbria	—	—	—
3	Yorkshire	679.0	704.0	680.5
4	Wales	36.0	22.5	11.5
5	Severn-Trent	—	10.0	27.0
6	Anglia	91.0	91.5	87.2
7	South West	7.5	11.0	11.8
8	Wessex	249.0	264.7	294.5
9	Thames	14.4	36.5	53.0
10	Southern	54.5	132.0	203.0
	Total	**1141.4**	**1343.2**	**1471.5**
Scotland Total		380.0	532.0	872.0
Great Britain Total		**1521.4**	**1875.2**	**2343.5**

Above: Trout rising to food on a trout farm. Most farm-reared trout are fed on a diet based on fish protein, starting at about 54% protein for fry and lowering the protein content as the fishes grow. As the trout grow, it is important to grade them into sizes, otherwise the largest fishes eventually devour the smallest ones.

Right: A river being stocked with trout. Many trout reared in Britain are sold to put-and-take fisheries, in which they are introduced to a stretch of water for the sole purpose of being caught.

A major problem for trout farmers is disease due to overcrowded ponds. The most serious is whirling disease, outbreaks of which have in the past caused trout farms to be closed down. This disease is caused by a protozoan attacking the inner ear of young fishes, causing them to lose their balance and swim around in circles. It is highly contagious and there is no sure cure.

How long the trout remain in the trout farm depends on their rate of growth, which in turn depends on their diet and the temperature at which they were raised. They may be as young as seven months when they are sold or released or they may be twice that age.

Fate of the fishes Trout farmed in Britain suffer one of two fates. They are either sold for the table or they are sold to so-called put-and-take fisheries. These are stretches of water, either private or owned by a Water Authority, in which the owner buys stocks of fishes, which are introduced for the sole purpose of being caught quickly.

The range of habitats into which trout are introduced varies from warm nutrient-rich lowland reservoirs to high-altitude acid lakes, such as those in north Wales. They may also be introduced at various stages of their life-cycle, depending on the needs of the consumer and the nature of the habitat.

Environmental problems Trout farms can create serious environmental problems. There is the pollution caused by the fishes' effluent, though this is now being solved by the installation of adequate treatment facilities. Connected with that is the problem of trout in a farm downstream being infected by diseased fishes from a farm upstream. Finally, there is the effect of escaped trout on the wild populations. This is not yet a major problem, but it is a factor for concern in assessing the impact of trout farms on the environment.

ALONG THE TOP OF THE COTSWOLDS

The Cotswolds, which usually evoke thoughts of honey-stoned villages and clear-streamed valleys, also have a more robust aspect. For at the escarpment edge, where the great limestone plateau confronts the vale of the Severn, the scenery becomes dramatic.

Above: Cotswold country – a patchwork of rich fields on the gentle slopes of the hills. Sheep once grazed over much of this land, giving rise to great local prosperity, as the many richly endowed 'wool churches' testify. Now intensive agricultural techniques have reduced the amount of unimproved grassland.

There is no better place to experience the scale and sweep of the great Jurassic escarpment of the Cotswolds than on Cleeve Hill. Lying 6.4km (4 miles) north-east of Cheltenham, Cleeve Hill is the highest point of the Cotswolds. For the walker this is generous country where a good footpath system provides a range of walks from an afternoon stroll to an energetic hike. The Cotswold Way represents the longest of the organised routes and, as a result of many hundreds of hours of effort voluntarily invested by ramblers and the Cotswold Warden Service, it may now be followed from Bath to Chipping Camden.

The waymarked route The route of our walk, which follows a section of the Cotswold Way, begins at the top of Rising Sun Lane. (A polite request to the proprietor of the hotel of the same name will enable you to make use of the hotel car park.) The first yellow arrow, the Cotswold Waymark, can be found on the footpath sign where the lane gives on to Cleeve Common. From here the route heads steeply upwards, passing groves of lime and sycamore and crossing fine limestone turf covered with bedstraws and thyme in summer. To the right may be seen the corrugations of an ancient earthworks known simply as the Ring.

The next waymark, one of the hundreds of such short posts scattered along the Way, can be seen by the right-hand fork in the track. There are fine views of the ancient Malverns to be seen from here. The path then slopes on upwards to a waymark post on the hill. A pause at this spot reveals a well-developed fairy ring in which hidden fungi nourish the grass in a lush green circle. The climb to the top is fairly steep, but from here on progress is quite easy.

A topograph has been installed on the summit, and a clear day reveals not only the

Cathedral of Gloucester, but also the Sugarloaf and Black Mountains of Wales, this scenery enhanced by the quilt-like spread of fields stretching to north and south. The nearby triangulation point is the site of the next waymark, which points to a group of radio masts. Just below the hill crest you can see a biological curiosity–a local outcrop of sand has given rise to an unexpected heath, with heather and lime-loving plants growing close together.

Passing the masts on the right of the Way, a second triangulation point marks the highest spot in the Cotswolds–330m (1083ft)–but the view is partially obscured. Some care should be taken at this point, for the Way forks left, at a heading of approximately 10 o'clock in relation to the drystone wall. Nearby, gorse bushes are scattered beside the path and beneath them coarse grass has choked out all but the most vigorous wild flowers.

Uninhabited Wontley Farm is the next landmark beyond the overhead power lines.

Above: The chalkhill blue butterfly can still be found on Cleeve Hill, as can the carline thistle on which this specimen is sitting.

Below: The autumn gentian–another Cotswold speciality.

The old buildings, nestling in a small dry valley, testify to agricultural change. A waymark on the corrugated iron by the farm gateway indicates a left turn. Alongside this track the drystone wall, like many on the Cotswolds, is too expensive to maintain and is therefore now fenced and tumbledown. Nearby acres of corn and ryegrass are evidence of the rich potential of Cotswold soil.

Clear waymarking soon brings you to Belas Knap, one entrance being obvious even from a distance. This is one of the most striking of the many ancient long barrows strung along the Cotswold scarp. A step further on reveals a magnificent view of Winchcombe and Sudeley Castle. This landscape is the essence of southern England, with its irregular geometry of woodland, fields and villages.

The return route Retrace the path to Wontley Farm, but here leave the Way for a detour and head straight on for West Down. Turning right at the old cattle grid, the path heads once more beneath power lines and back to the radio masts. The grass nearby is rank, but patrolled by butterflies on warm summer days. From the masts the return route skirts the scarp edge, giving a closer view of Cleeve Cloud Hill Fort. This is one of the many defensive earthworks built in ancient times on suitable promontories along the escarpment.

Below the fort, Cleeve Cloud itself is worthy of inspection. Here the geologist will find, in the old quarry working, good exposures of various types of rock strata, showing the current bedding. By following the scarp you return to Rising Sun Lane, the start of the circuit.

Once downland, now arable From the time of the Romans until the enclosures of the 18th and 19th centuries, the Cotswolds were open downland. Close grazing by sheep favoured the growth of fine-leaved grasses, and turf of extraordinary richness developed over the limestone. Cleeve Hill is typical of the rich sward which forms on this thin soil, and over 200 species of plant–50 of them rare or local –have been recorded here. This is, in part, due to local variations in soil types, sands, clays and Fullers Earth outcropping here and there, particularly in valleys and on the scarp

slope.

For centuries the sheepwalks were the basis of the Cotswold economy. However, recent changes in farming from extensive to intensive techniques have led to a much-reduced area of unimproved grassland. Arable crops are now widely cultivated on the Cotswold plateau, and the contrast between lush green fields and the encircled Common at Cleeve is a marked one. Indeed, it is largely the common land status and the steepness of the scarp slope which have preserved surviving remnants.

A wealth of wild flowers The escarpment edge may be a bleak and barren place in winter, but these same grasslands become a glory of wild flowers from spring to autumn. Many Cotswold flowers, such as cowslips, oxeye daisies and field scabious, may be found elsewhere in the countryside, but the lime-rich soils also support a variety of specialities. Chalk milkwort and yellow wort, for example, are restricted to lime and their presence is a clue to soil conditions beneath. But apart from an abundance of calcium, the soil is generally poor in nutrients and nitrogen-fixing plants are at a definite advantage. Bird's-foot trefoil, hop trefoil, clovers and vetches therefore play a vital role in the nutrient economy.

Cotswold grassland is well-endowed with members of the thistle family. On Cleeve Hill the carline thistle may be found at any time of year, its curious flower head persisting in dried form through the winter; the stemless thistle, growing flat to the ground, is easier to overlook when not in bloom. The most extravagant of the group, however, is undoubtedly the woolly thistle, whose large flower heads are borne on stems up to 1.8m (6ft) in height.

Above: If you have keen hearing—and visit Cleeve Hill in the summer—listen for the whirring, almost grasshopper-like song of the grasshopper warbler. This well-camouflaged little bird is a summer visitor and extremely secretive, hiding in thick herbage or low scrub.

Below: The route of our walk. Take warm clothing with you, even in summer. At over 305m (1000ft) in height, the top of the Cotswolds can be chilly.

But of all the wild flowers, it is the orchids that are the most interesting. Ten species have been recorded from Cleeve Hill, although their annual appearance is always unpredictable. The bee orchid, in particular, is notorious for its ability to reappear in an area after many years' absence; in 1981, for instance, it unexpectedly blossomed on road verges and beside gravel pits, and even on aerodromes in Gloucestershire. A visit to Cleeve Hill in early July should be rewarded by the lovely fragrant orchid which attracts butterflies and moths with its rich perfume. Common spotted and early purple orchids are usually common, and the modest twayblade is also to be found.

Animal life It is no surprise that this wealth

of wild flowers is accompanied by a great variety of insect life. Grasshoppers, beetles and bugs abound, and butterflies still swarm on flowering Cotswold banks. A summer's day on Cleeve may bring out drifts of blues, skippers and browns, the latter including the delicate marbled white which graces thistle heads in July. Large and small skippers are present on Cleeve, and are particularly numerous in the longer grass by the track on West Down. Of the blues, neither the Adonis nor the large are now to be found in Gloucestershire, but the common, chalkhill and small species are still locally plentiful.

While most of us are fond of butterflies, slugs and snails have fewer friends. Yet the Cotswold grasslands are a source of interest for the large Roman snail which may be encountered on moist mornings on many sites in Gloucestershire. Its method of arrival in this country is still a matter of some debate, although the theory that it was introduced by the Romans has a romantic attraction. Whatever its origins, its future is now threatened by gastronomic greed: there have been recent instances of restaurateurs stealing Roman snails from Cleeve Hill.

Though it is not a bird-watcher's paradise, people with keen hearing may detect the whirring song of the cryptically coloured grasshopper warbler on Cleeve Hill. This secretive little bird arrives in the area in most summers, and is much easier to hear than to see. The stonechat is frequently present, together with the occasional whinchat enjoying the gorse bushes which cover several large tracts of the Common. Of birds of prey, the kestrel appears occasionally and a buzzard may sometimes be seen spiralling in the warm thermals over the escarpment, searching for prey far below.

Above: The remains of many villas are evidence of the Roman settlement in the Cotswolds. Whether the Romans in fact introduced the Roman snail (shown here) is debatable; nevertheless, this attractive mollusc can be found on moist mornings in many parts of the Cotswolds.

Right: The fragrant orchid flowers on Cleeve in early July. It is possible to find ten orchid species here, but some are very unpredictable.

Below: Built by New Stone Age people in about 4000BC, the mound at Belas Knap long barrow covered 38 human burials. Today the barrow is maintained by the DoE. The flowers in our picture are spikes of rosebay willowherb.

GIANTS FROM THE AMERICAN WEST

Two of the tallest species of tree in the world – the wellingtonia and the coast redwood – come from the west coast of the United States, where some exceed a height of 90m (300ft). Introduced to Britain in the last century, they now provide us with some of our most spectacular trees.

The wellingtonia is one of the largest and most stately conifers to be found in Britain. Several specimens are around 45m (150ft) tall, and the largest is 47.2m (155ft), but in its native North American habitat it may reach 75-90m (250-300ft), with a huge tapering trunk 6-9m (20-30ft) wide at the base.

Spongy bark Wellingtonia is an easy species to identify. From a distance its rich dark brown or red bark is a characteristic feature. The bark can be 30-60cm (1-2ft) thick and is extremely spongy, which means that you can punch it hard without any fear of being hurt – a useful way of identifying it! The lower part of the tree tends to be bare of branches and the crown of the tree is narrow. In Britain, because it is likely to be the tallest tree for miles around, the crown is often rounded as a result of being struck by lightning.

The leaves are blue-green, hard and awl-shaped, tapering from a broad base to a fine point. They lie along the twigs, overlapping each other and pointing forwards, with their tips curling out away from the twigs. When crushed they smell strongly of aniseed.

For such a large tree, the cones are surprisingly small, growing to a length of no more than 8cm (3in). They are more or less spherical in shape and the cone scales have a characteristic groove.

American native The wellingtonia is native to California on the west coast of North America, where it is found on the western slopes of the Sierra Nevada mountains, usually growing at an altitude of 1400-2100m (4500-7000ft). It was discovered in the 19th century, when North America was being combed by botanist-explorers looking for plants to take back to Britain. The first European to see a wellingtonia was John Bidwell in the autumn of 1841. In 1853 it was introduced to Britain and was named the wellingtonia, after the first Duke of Wellington, by the great English botanist John Lindley.

The discovery of this huge tree was an important botanical event to the Victorians, who were fascinated by extremes of size and shape in the plant kingdom. The ages of some of the trees in the wild created a sensation. One tree that had been felled was estimated to be 3000 years old. Lindley wrote that 'it must have been a little plant when Samson was slaying the Philistines.'

Growing wellingtonias soon became something of a craze. Veitch's famous nursery was selling plants by 1854 and they were soon growing fast in the extensive arboreta and gardens of the time. It was also widely planted in churchyards, where many of the best specimens are still to be seen.

Thoughtless destruction Sadly, however, the discovery of wellingtonia trees was quickly followed by their destruction as the lumber merchants and the tourists moved in. A chalet hotel was built in one of the wellingtonia groves, with a dance floor created out of the massive stump of one tree. By the 1870s, there were five saw-mills cutting up the best and biggest of the trees. One mill was said to have cut a staggering 2 million cubic feet of the timber in one year alone.

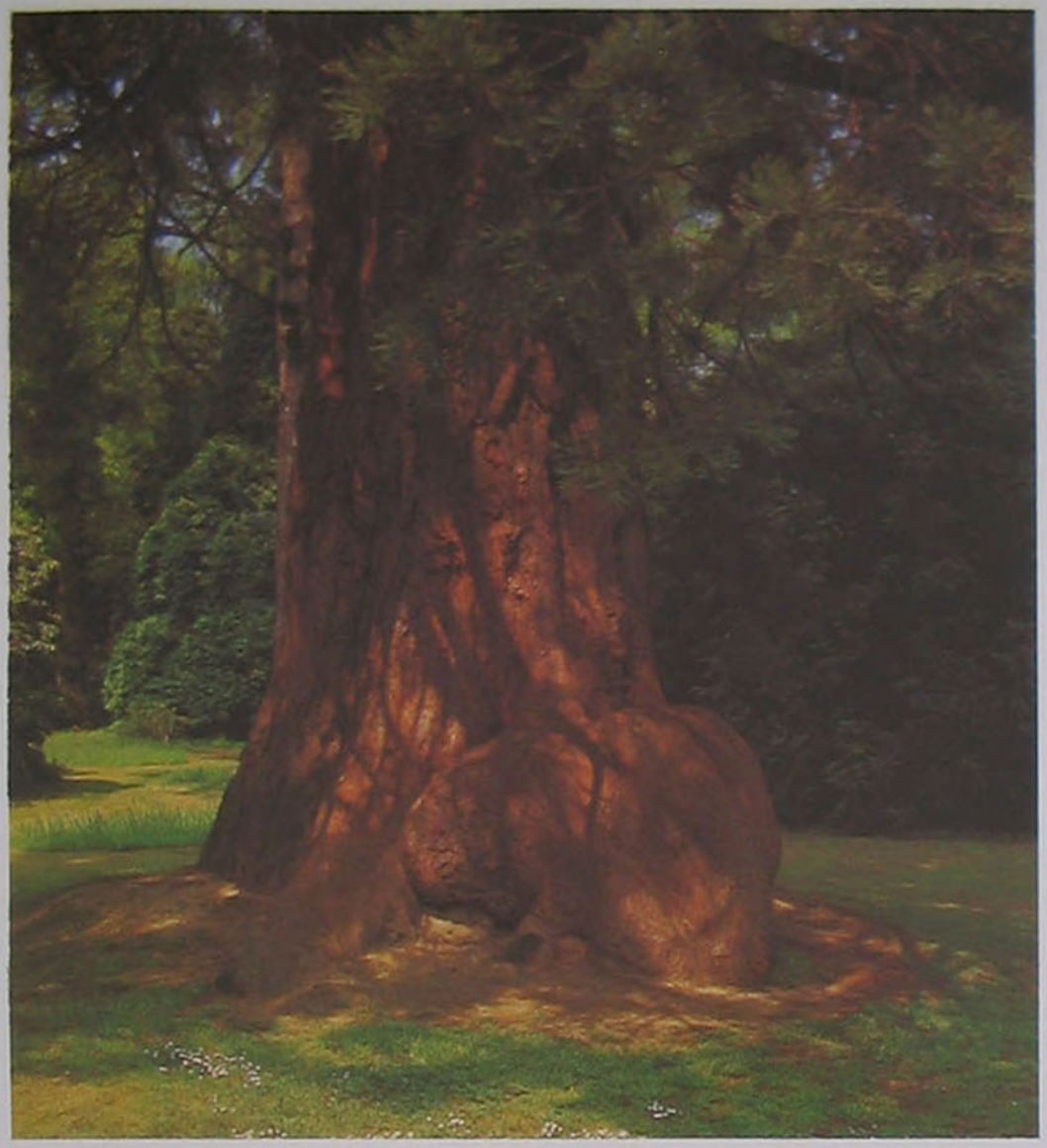
The rate of destruction shocked the Victorians, and botanists predicted that the wellingtonia would be extinct by the end of the century. As a result of the agitation, the best remaining groves had, by 1900, been protected, though by then all the tallest specimens had been cut down. The wellingtonia groves now form a part of the United States' National Parks.

The devastation at that time is similar in some ways to the present-day destruction of

Wellingtonia
(Sequoiadendron giganteum)

Coast redwood
(Sequoia sempervirens)

Below: The male cones of a wellingtonia are borne on the tips of the shoots. They turn yellow and release their pollen in the spring. You can recognise the trunk of a wellingtonia because it is so soft and spongy that you can punch it without fear of hurting your hand.



our tropical rain forests. The timber of wellingtonia is very brittle and has little economic value. It was used for mundane purposes, such as fencing and roofing, and the timber companies did not, in the end, make much profit out of their destruction. In much the same manner, the rain forests of today are being felled and burned without the timber being properly used, and so it is bringing hardly any benefit to the people of the country concerned.

Relic of the past Most wellingtonias seen growing today date from the second half of the 19th century; they are much less planted now than they used to be. With their dark, gloomy appearance, they cannot be said to fit happily into the British landscape and, moreover, the days of planting grandiose trees such as the wellingtonia in large private arboreta seem to be gone. Today, they are much more a relic of our Imperial past than trees for the future.

Coast redwood A close relative of wellingtonia is the coast redwood. Although it belongs to a different genus–wellingtonia being *Sequoiadendron giganteum* and the coast redwood *Sequoia sempervirens*–they are both members of the same family, the swamp cypress family, Taxodiaceae.

From a distance, the coast redwood looks very similar to the wellingtonia, with its huge tapering trunk, red bark and slender conical crown. Close to, however, the species are easy to tell apart. The bark of a coast redwood, though red and equally thick, is stringy rather than pulpy. It is also much harder and it would hurt to punch it.

The foliage is also quite different. The leaves are much thinner and they are arranged in opposite rows along the twigs–the typical conifer arrangement. Underneath, the leaves have a prominent white band on each side of the midrib. On the leading shoots, the leaves are shorter and arranged around the tip of the shoot, instead of in opposite rows. The cones are smaller than those of wellingtonia–about 2.5cm (1in) long–and bear the same groove in their scales.

Native habitat The coast redwood comes from the Pacific coast of North America, from the southern tip of Oregon south into California. It grows in a narrow belt along the coast (hence its name) which, in the summer, is frequently covered in mist from the Pacific Ocean, providing the tree with an excellent source of moisture. In its native habitat it can grow to be even taller than the wellingtonia, sometimes reaching as high as 110m (350ft). In Britain, it grows best in the damp climate of the west of England, where it can reach a height of 40m (130ft) or more.

In the open, it may bear branches from close to the base upwards but in its native forests, where it grows in deep shade, the lower branches tend to die and fall off, leaving a clear bole often as high up as 25m (80ft).

Above: In its natural habitat, the base of a wellingtonia can be as much as 9m (30ft) wide. Some idea of the size of these giant trees can be gained if you go to the Natural History museum in London, where there is a massive cross-section of a wellingtonia trunk. This trunk is 4.5m (14ft) across and the tree from which it was taken was estimated to be 1300 years old when it was cut down in 1892.

Opposite page: The rich brown tapering trunk and the narrow conical crown make the wellingtonia easily recognisable from a distance, but the size of many specimens alone should indicate the species.

Right: The coast redwood is often seen with suckers growing round its base. A similar, though more unusual, form of reproduction is shown here, where a knot (called a burl) from the trunk of a coast redwood has begun to sprout after breaking off.

BACTERIA AND VIRUSES

So small that they can be seen only with the aid of powerful microscopes, bacteria and viruses nevertheless have a great effect on our lives, for both better and worse.

Above: Some bacteria obtain their energy via light, in a similar manner to green plants, whereas others use chemical means. An example of the latter group is iron bacteria. This is a group of filamentous bacteria that occur in stagnant water containing iron. They obtain their energy by converting dissolved iron salts in the water into a form of brown rust, which is deposited on the bottom of the pool, on stones and on the surface of submerged plants.

With the study of viruses and bacteria we enter the realm of microbiology, for both types of organisms can be seen only with the aid of powerful microscopes. Bacteria are usually between one and ten micrometres long (a micrometre being a thousandth of a millimetre) and viruses are even smaller–sometimes only a fiftieth of a micrometre in length.

Single-celled bacteria All bacteria are single-celled organisms in which the cell contents are enclosed in a membrane which, in turn, is surrounded by a thick rigid wall. Inside the cell are various structures, including the nucleus which contains all the information about the cell so that it can reproduce itself, ribosomes to manufacture the proteins it needs, and enzymes to produce energy. Some bacteria also have whip-like flagellae on their surfaces. By beating in unison, the flagellae propel the bacterium through its fluid medium.

Bacteria feed by absorbing nutrients through their cell walls. When they have grown to their full size they divide into two to produce a pair of new individuals, a process referred to as binary fission. A few species can also reproduce sexually: two bacteria join together and pass chromosomes between them; they then separate and divide into two.

Some species of bacteria can grow extra protective coats around their cell walls, converting themselves into highly resistant spores. This allows them to survive adverse conditions, such as extreme heat and cold, sometimes for several years. With the return of more suitable conditions the bacteria lose their protective coats and continue to develop. Some examples of spore-forming bacteria are anthrax (*Bacillus anthracis*) and botulism (*Clostridium botulinum*).

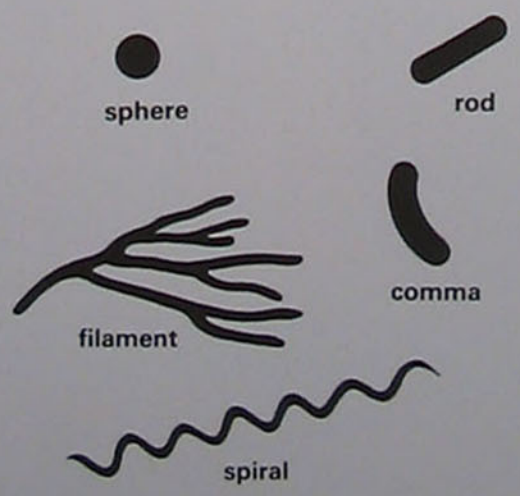
Harmful bacteria Most people think of bacteria as a source of disease and, indeed, they are responsible for many diseases affecting man, animals and plants. In Britain, one of the most common bacterial diseases is *Salmonella*, a form of food poisoning. With modern standards of hygiene this disease is now much less prevalent than it must once have been.

Bacteria can be transmitted not only on contaminated food but also on dust particles and on microscopic droplets of saliva and mucus, notably during sneezing. The bacteria that cause tuberculosis and pneumonia are spread in this way. A more direct method of transmission is shown by the bacterium *Clostridium tetani*, which causes tetanus or lockjaw. This bacterium is found in the soil and on vegetation. It enters the body via wounds in the skin and, once inside, produces a powerful toxin which can be fatal.

Bacteria can also cause serious diseases among animals, anthrax and brucellosis or undulant fever being particularly unpleasant. Plants are less affected by bacterial diseases, though examples such as fireblight and

Shapes of bacteria

Bacteria occur in a variety of different shapes. The three main ones are spheres, rods and commas (scientifically called cocci, bacilli and vibrios). Less common are long branching filamentous forms and wavy corkscrew forms called spirals. Bacteria vary greatly in size according to their stage of development, but the usual length is between 1 and 10 micrometers.



potato blackleg are familiar to many gardeners.

Beneficial aspects With such a list of diseases to be laid at their door, it is not surprising that bacteria are generally regarded as harmful. Yet, they also perform many useful, and sometimes vital, roles. Along with fungi, bacteria are responsible for the decay of dead plants and animals. Without this activity, the world would be full of carcases and vegetable remains, and the chemicals within them would not be returned to the environment for future generations to use.

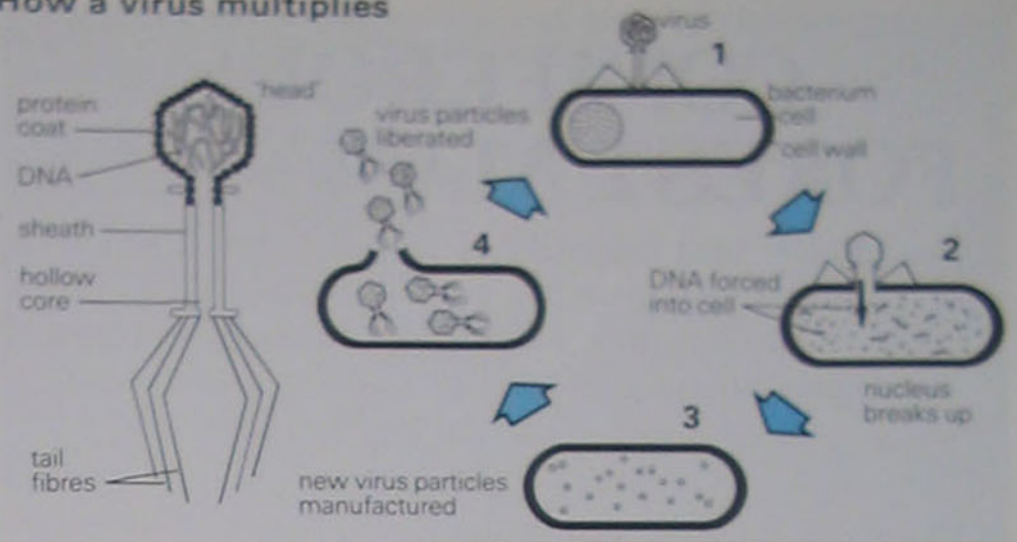
Leguminous plants benefit from the soil-dwelling bacterium *Rhizobium*. This organism infects the roots, causing the formation of nodules inside which the bacteria convert nitrogen into a form usable by the plant.

Other bacteria are essential in the nutrition of animals. In the primary stomach of ruminants, such as cattle and sheep, the vegetation they feed on is fermented by various bacteria to convert the cellulose and starch into nutrients that the animal can use for growth and energy. Carnivorous animals, and omnivores such as man, are less dependent on bacteria for their nutrition. However, our lower intestines do house several sorts of bacterium that provide us with certain essential items, most importantly the B group vitamins.

Man utilises bacteria in many different ways. He uses them to break down waste material during the purification of sewage in sewage works. A common bacterium called *Bacillus subtilis* is incorporated into biological detergents to act as an enzyme and remove stains caused by proteins such as blood.

Living or not? Viruses lie on the borderline between the living and the non-living. They cannot perform activities that we associate with living organisms, such as respiration, nor can they manufacture their own proteins

How a virus multiplies



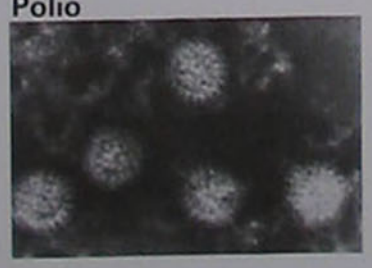
Above: The T4 bacteriophage (above left) parasitises bacteria. A virus lands on the outer surface of the bacterium (**1**). It contracts its sheath, penetrates the cell wall and forces the DNA in its 'head' into the cell (**2**). The DNA attacks the bacterial nucleus, breaking it up and causing the nucleic matter inside to manufacture new virus particles (**3**). Finally, the young virus particles are liberated and invade other bacteria (**4**).

Right: One of several bacteria found in man's intestines is the rod-shaped *Escherichia coli*.

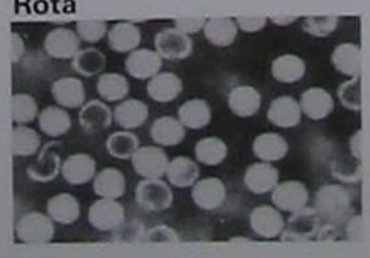
Below: Viruses occur in a range of shapes and sizes, usually a small fraction of a micrometre across.

Influenza

Polio



Rota



Common cold

Rabies

or energy, as can single-celled organisms like bacteria.

Viruses are packets of nucleic acid – DNA or RNA (the substance that controls the synthesis of proteins) – surrounded by a protective coat of protein. They exist in a variety of shapes, some being spherical, others rod or bullet shaped, while the T4 bacteriophage resembles a lunar landing craft.

Since they cannot manufacture their own energy or protein, the only way a virus can survive is inside a living cell. When a virus particle (a virion) enters a cell it causes the cell to produce more virus particles which break down the cell wall and are then liberated to invade other cells.

Viruses and diseases Viruses are of little benefit to man, apart from playing a small role in controlling pests. But they are responsible for some of his most virulent diseases, for example measles, influenza, the common cold and polio. In animals, viral diseases include foot-and-mouth disease and rabies, both highly contagious. Because viruses use the host's own cells to reproduce, eradication is almost impossible.

Apart from fungi, viruses are the most common cause of disease among plants. Typical symptoms of a viral attack are stunted plants with distorted leaves which often show yellow blotches and spots. An example is tobacco mosaic virus, which attacks a wide range of plants including potatoes and tomatoes.

CONIFEROUS FOREST MAMMALS

Although the vast majority of woodland planted today consists of fast-growing conifers, these areas are not devoid of wildlife. Many mammals have adapted well – particularly in younger forests – and some, such as deer, are on the increase.

Below: Fox in a tricky high spot? Although foxes do not usually live up in pine trees, this kind of picture is not as unusual as many people might suppose. Foxes are spectacularly successful mammals and have adapted well to 20th century environments. Their liking for urban living is well-documented, but in the last 40 years they have also colonized plantations in such areas as Royal Deeside in north-east Scotland.

In early times, more than half of the British Isles was covered in woodland. As man's population increased and his demands for timber and land for farming grew, more and more of our natural woodlands were felled. By the beginning of this century less than four per cent of the land surface was wooded.

Associated with this dramatic decrease in the extent of our forests was the decline of many mammals dependent on them and, of course, the extinction of some such as the beaver, wild boar, bear, wolf, moose and reindeer. Since the 1920s, however, there has been a vigorous national policy to increase our own timber production, rather than rely on imports.

About eight per cent of the British Isles is forested, and the figure is increasing yearly. The new plantations are mainly of introduced, fast-growing conifers and are a far cry from the vast oak, birch and Scots pine forests of the past. They do not have the varied structure of natural woodland, and are often considered to be not only an unnatural, but also a sterile environment for wildlife. Just how true is this? How do our mammals fare in these new habitats?

Effect of afforestation When deciduous woods are replaced by even-aged stands of conifers many forms of wildlife are affected, including some mammals. Dormice, bank voles and wood-mice depend greatly on deciduous woods or their margins, and so can only suffer from their demise.

By far the greatest impact on our animals is seen in northern Britain, and particularly in Scotland, where more than half of our plantations occur. Here there is a marked change in the countryside, for these new forests are not supplanting old woods but are being established on open-hill country which was previously used for grazing sheep (sheep-walk), or as deer-forest or grouse moor.

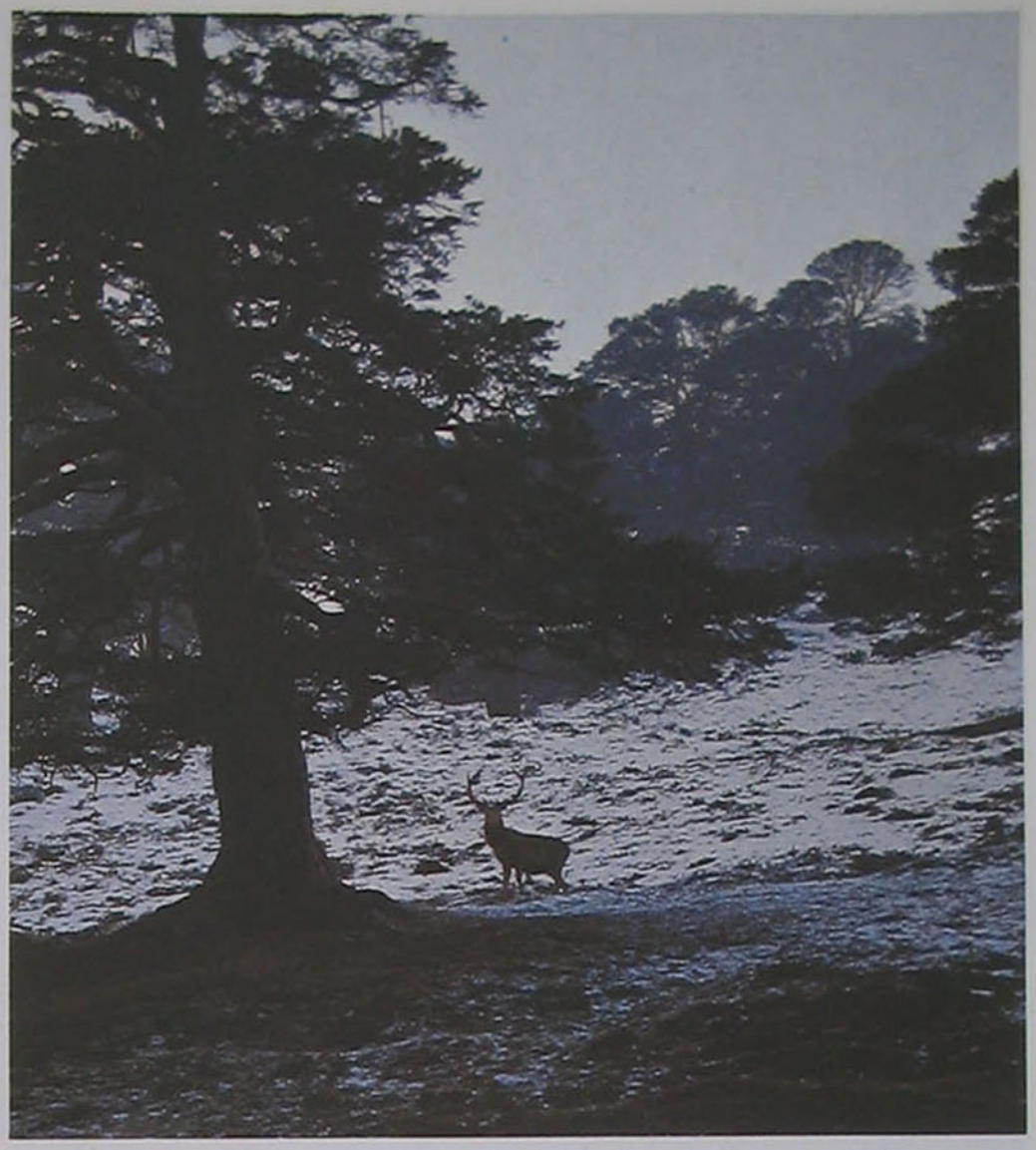
Perhaps surprisingly, many people believe that most of the effects of such afforestation are beneficial. In the early stages of a plantation, before the canopy closes and light is excluded, field voles increase in numbers considerably. On open sheep-walk or moorland

you might expect to find about four per acre, but this rises to about 50 per acre in young plantations, and in exceptional years as many as 1200 per acre have been found. The change in the composition of the grassy swards and their tussocky nature, following ploughing and fertilising prior to planting the young trees, gives the voles food and the cover needed to make their runs. The increased insect fauna in the early years of the plantations encourages small insectivores, such as the common and pygmy shrews. As the forest grows, however, the ground vegetation is shaded out and dies, and the small mammals are then concentrated on the rides and firebreaks between the forest blocks, or on open areas within or just outside the forest boundaries.

While the small mammals suffer from the growth of the forest, the larger ones benefit from the increased amount of tree cover. Deer use the older stands for shelter and for protection from disturbance, periodically coming out to the open areas to feed. The carnivores also seek the refuge given by the taller trees, venturing out to hunt only at night.

More large mammals The group of mammals that have benefited most are undoubtedly the deer. The delicate and elusive roe deer are spreading throughout the country, as indeed they are throughout northern Europe, and they are particularly numerous in younger forests. Their spread is helped by the scattered nature of our plantations, especially in England and Wales, so that when the young disperse from their parents' home ranges they can 'leapfrog' from forest to forest, thus spreading very quickly.

Another small deer to benefit from forestry in the south is the muntjac or barking deer. Originally an escape from Woburn Park in Bedfordshire this tiny deer – no bigger than a labrador dog – is now found in most counties of southern and central England as far west as Devon, and it is still increasing its range. In fact, it was not until the particularly hard winter of 1962-3, when many animals died of exposure, that the extent of its range was realised.



Above: Red deer stags foraging in winter in old Caledonian pine forest in the Cairngorms. Red deer have also now colonized most plantations in north and western Scotland and live within the forest boundaries throughout the year.

Left: Wild cats are no longer confined to remote hills in northern Scotland. They take advantage of food, such as voles, found in young plantations, and may venture on from there to towns – one road casualty was found to have more than 200g (7oz) of ham in its stomach.

Even the mighty red deer are spreading. Many people still think of them as creatures of open-hill ground which are driven into low-lying plantations only during bad weather in winter. This could not be further from the truth – and in Europe they are always woodland dwellers. They have now colonized most plantations in northern and western Scotland and live within the forest boundaries throughout the year. Their forest populations frequently match or surpass those living on open ground and they are soon expected to colonize the vast expanse of forestry in the Border Country.

Sika deer were introduced into deer parks in several parts of Britain in the late 19th century. Over the years they have escaped and have established feral populations. In Scotland there are many growing herds and they are spreading through the forests. This species can hybridise with the native red deer, making it difficult to maintain a pure stock of either species. Because of their particularly elusive and secretive nature they are difficult to keep in check.

Above: A pine plantation in a New Forest enclosure. Pine plantations may appear still and lifeless, especially when compared with areas such as the New Forest which abound with rich broadleaved woodland, but on poor upland soils they provide a welcome habitat for a number of animals and plants. Perhaps the only mammal to suffer from the afforestation of hill land is the mountain hare. However, even it will live in forests, particularly when there is adjacent hill ground or open heather moor.

Left: Red squirrel in a spruce tree. The typical habitat of this mammal is a mature plantation of Scots pine with reliable cone production, but it also thrives in larch and Norway spruce plantations.

The carnivores, too, have gained from the increase in forestry. The number of gamekeepers has declined over the last 30 years, so there is less persecution, but the refuge given by the numerous thick plantations has also played an important part in their recovery. Foxes are now numerous in these habitats, and wild cats and pine martens are more common in areas around Royal Deeside.

Different types of forest? There is much discussion about planting more diverse species of trees. A variety of species certainly produces varied landscapes of trees of different forms and colours but will it affect our mammals much? If we consider planting just different species of conifers, then the answer is probably no. Most mammals depend not on the trees themselves for food, but directly or indirectly on the ground vegetation or the cover given by the forest. The red squirrel may be an exception: it can live in mature conifer forests of any species, but it does best where the dominant tree is the Scots pine.

The greatest gain for the mammal fauna in our woodlands would be the planting of deciduous trees that encourage a more diverse vegetation and its associated insect life. But for economic reasons the amount of hardwoods planted in northern Britain will be a small percentage of the total forested area, and so we have to make the best use of them.

The crucial questions, for which we have no good answers at present are: what is the

minimum size of deciduous wood that will enhance the existing, or support its own mammal population; and, do we need several small blocks of hardwoods or a few large ones alongside coniferous plantations?

Leaving strips of trees along streamsides may look attractive, but because of their small extent they probably do not help the mammal fauna, nor indeed our song birds, very much. We need to know much more about the size and distribution of these islands of deciduous trees if we want to increase the numbers and diversity of our mammals and birds.

Can we do more? Set against the problem of conserving mammals in forests is the fact that many are pests. Even trying to encourage non-pest species by altering the habitat could encourage the pest species. Further, what is a pest in one area is often an asset in another. Obvious examples are the red squirrel and red deer which could well be encouraged in parts of England and Wales, where there are small populations, but certainly not in northern Scotland. It is very difficult to have a national policy when local conditions vary so much throughout the country.

Conflict The herbivores are the main source of conflict between the forester and the conservationist. The damage caused by deer in particular can be most severe. They eat the leading shoots of important trees, and red and sika deer, as well as feral goats, also eat the bark of some trees, so making the trees vulnerable to damage for most of their lives. Nothing is more frustrating for a forester than to nurture a crop of trees for 40 years, only to see it ruined overnight by severe bark-stripping from deer.

In our natural woods, rabbits, hares and voles frequently attack our native woods, such as the native Caledonian pine forests of Scotland. In many areas these are moribund, with little or no regeneration because of the pressure from deer and other grazers. So we should not be too sentimental about culling deer, for example. If they are properly controlled and managed, the habitat is enhanced for many other forms of wildlife. Many mammals must be controlled in the forests for the sake of the forests themselves; proper management is the key to the conflict between the forester and the conservationist, and with goodwill on both sides, a balance can be reached.

The future As our forests mature, are felled and replanted, we will have a much more varied forest both in age and structure than the more even-aged plantations of today. This will be favourable to wildlife, even if it will never be as attractive as our ancient and natural woodlands. These dark green islands in our countryside will remain important reservoirs for our mammals, and perhaps future generations of people in Britain will come to regard and accept these conifer forests as 'natural' in the same way that we now accept our native deciduous woodland.

Right: Field voles are common mammals and they are especially prolific in the thick grassy areas of young plantations where they find good supplies of food and cover. The populations decline as the trees grow tall and shut out the light.

Below: A roe deer calf. This species is spreading throughout the British Isles and Europe, and it does particularly well in younger forests.

A QUESTION OF SPINES

Why do some plants have spiny leaves, thorny branches or prickly fruits? These are not decorative features–each one plays an important part in the successful growth of a plant.

Above: Wild roses have no need to grow their own stout, supporting stems–their hooked prickles anchor them firmly on the branches of the hedges among which they grow. This enables them to grow up into the brightest sunlight.

Below: Prickles, and the much smaller pricklets, on a bramble stem. Such an armoury of spines is both a protection against grazing animals and a means of holding on to surrounding plants.

Broadly speaking, a spine is any part of the plant that is stiff and sharply pointed, but the use of the word is often limited to structures which are either part of a leaf, or a whole modified leaf. Although we tend to use the terms spines, thorns and prickles indiscriminately, they are actually used botanically to describe very specialised structures.

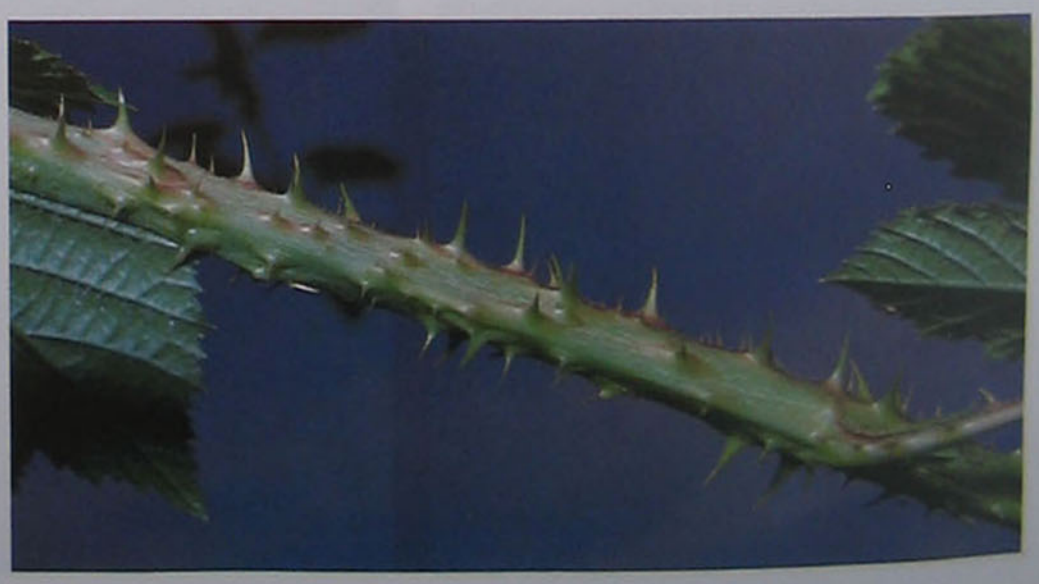
Thorns, for example, are hard, woody modified shoots or branches and contain within them the water conducting tissues of a normal branch. They generally occur on woody plants, especially shrubs and small trees and, since they are modified branches, the arrangement of thorns on a plant usually follows the branching pattern of the plant. As a result, they may occur in a regular or symmetrical way. Some thorns continue to grow as the plant ages because they have regions of active growth corresponding to those of a typical branch. Many thorns even produce leaves along their length, just as normal branches do. Thorny species include hawthorn and gorse.

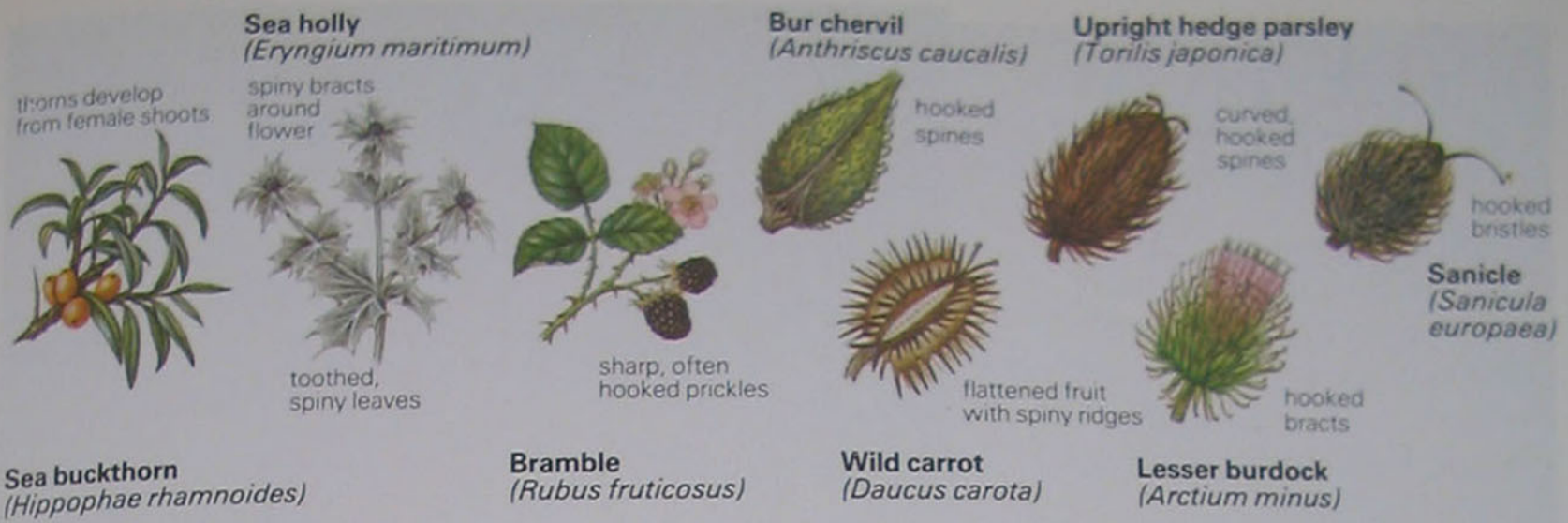
Prickles differ in being sharply pointed structures arising from the outermost layer, or epidermis, of stems or leaf stalks. They are simply a much larger, woody version of the stiff hairs that cover some plants, and are not modified leaves or branches. Prickles also differ from thorns in that, as they arise from the epidermis, they do not show any regular arrangement. Smaller prickles found scattered among the larger ones are sometimes called pricklets. Structures often referred to as thorns on brambles or roses are actually defined botanically as prickles.

Varied functions Spines, prickles and thorns all perform functions which contribute to the plant's successful growth, often by helping to make it better suited to its environment. The spines often protect a plant against grazing animals, or they provide a means of climbing over neighbouring plants to compete for sunlight. Alternatively, they may help to reduce the surface area of the plant by replacing leaves in an effort to conserve water, or help to disperse the fruits or seeds. Often, two or more of these functions may be recognisable in one species of plant.

Prickly family Some families of plants include more species with spines than others. The rose family has numerous species with either prickles or thorns–features which are obvious in such species as wild roses and brambles.

The method by which these species climb is very simple but extremely effective. The young branches of roses, for example, grow vertically and very rapidly until their weight causes them to arch over and their prickles then catch on to the branches of surrounding plants. This gives them support so they can continue to grow upwards. In some brambles, the prickles are hooked and backward-pointing so they are not easily shaken loose.





Specialised thorns Woody members of the rose family, such as sloe and hawthorn, have thorns with leaves growing along their length. The thorns may be more obvious in autumn and winter, for they persist from one season to the next, whereas the leaves do not.

The thorns of some species develop in rather unusual ways. Those of the sea buckthorn, a species which has separate male and female flowers, develop from the female shoots when flowering has finished, rather than from vegetative branches. Those of purging buckthorn, a thorny shrub or small tree, grow only at the ends of the short, lateral branches and not from the main branches themselves.

Protection and defence Very spiny in appearance, all three species of gorse are defined botanically as thorny, the main purpose of the thorns being to protect the plants from herbivores that might try to eat them.

However, the thorns of gorse are not only protective, they also constitute a large proportion of the green, photosynthetic part of the plant. Although gorse species do have leaves, they are small and scale-like, borne along the length of the thorns and contributing relatively little to the production of sugars for energy by photosynthesis.

A common arrangement is for plants to have normal leaf blades with spiny margins. This allows photosynthesis to be carried out as in a normal leaf, and also gives protection from grazing. The thistles and holly are familiar examples of plants of this kind, while the unrelated sea holly also has spiny leaves.

Spines for dispersal The spines of some fruits are aids to dispersal. Goose grass and sanicle both bear small rounded fruits whose minute spines have hooked or barbed tips which can catch in the fur or feathers of animals, and so carry the fruits far from their point of origin. The fruits of hedge parsleys possess spines in a variety of forms: those of spreading hedge parsley are curved but lack hooks, while those of upright hedge parsley are always hooked. Burdocks have hooked bracts which function in the same way, dispersing whole heads of fruits together.

Top: Plants with spiny fruits spread easily to new locations. Whether ringed with spines, bristles or bracts, the fruits become entangled with passing animals and are dispersed far and wide.

Above: The impressive spiny thorns of gorse are an effective defence against grazing animals. On the heaths of the New Forest, for example, impenetrable thickets of gorse grow where grazing by ponies limits the growth of other plants.

Spines for water conservation

Extreme reduction of leaves is a feature of desert plants such as cacti, which need to decrease their surface area to reduce water loss. Some plants have spines which virtually replace the leaves and serve a similar purpose—reducing the plants' surface area and so helping to conserve water. Saltwort (right) which grows in coastal salt marshes where the soil is salty and the plants may be inundated by high tides, exhibits such characteristics. Fresh water is scarce there and must be hoarded inside the plant, so the leaves are reduced to the spiny-tipped minimum to conserve water.

SEE HOW THEY RUN

Although they are often referred to disparagingly as 'creepy-crawlies', insects – endowed with six legs – in fact have a variety of different methods of locomotion.

The three pairs of legs all insects have are used in a variety of ways – for walking, running, crawling, jumping or swimming. These various locomotory activities sometimes involve all six legs, but at other times only two or four of them are used.

High-speed beetles In insects such as beetles which use all six legs, movement is fairly straightforward when the insect is progressing slowly. The first and third feet on one side and the second foot on the other are planted firmly on the ground so that the insect is supported on a tripod. A backward push by these three legs then carries the insect forward; at the same time the other three legs are moved forward and planted to repeat the motion. When the insect is moving rapidly this simple pattern of shifting tripods becomes complicated by a series of variations.

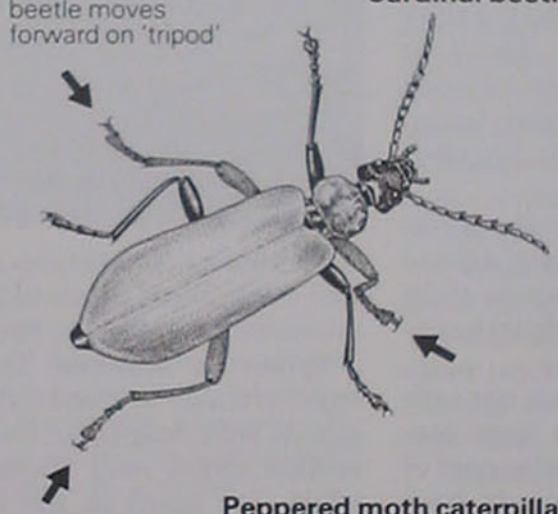
The most active runners among insects include several species of beetle. A tiger beetle, for instance, can cover 60cm (2ft) in one second, which may not seem particularly fast, but a horse would have to run at a speed of 250mph to cover its own length as fast as a tiger beetle.

In contrast to the beetles, some flying insects hardly use their legs for locomotion at all. Butterflies, for example, are not good at walking, such species as the red admiral having stunted front legs which are useless for walking, serving only as organs of taste. Moths vary in their ability to walk and run. One species, the mouse moth, is well known for the way in which it scuttles about but another, the female vapourer moth, hardly uses her legs for moving at all.

Most insects which run and walk can also climb; their feet are normally equipped with sharp claws for ascending rough surfaces, and with small adhesive pads for negotiating smooth ones.

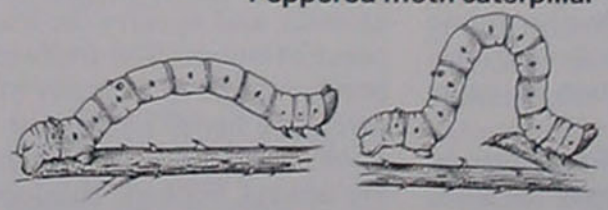
Larval locomotion Butterfly and moth caterpillars and some species of sawfly larvae (those resembling caterpillars), have three normal pairs of jointed legs situated just behind the head, and a series of fleshy false legs or 'prolegs' along the hind part of the body. The number of these prolegs differs – moth and butterfly caterpillars usually have five

Cardinal beetle



Above: When moving slowly, the cardinal beetle's legs follow a simple pattern. The front and back legs on one side and the middle leg on the other side (arrowed in the diagram, left, top) are placed on the ground, supporting the insect on a tripod. It is then carried forward by a backward push of these legs. Simultaneously, the other three legs move forward and are planted on the ground. The pattern is then repeated.

Peppered moth caterpillar



Below: Caterpillars move forward in two different ways. Some species, such as the peppered moth caterpillar (left, bottom) advance in a looping motion, while others, such as the privet hawk-moth larva (below) progress by crawling along.

pairs, while sawfly larvae have six to eight.

These larvae crawl by extending the front of the body and the true legs, then moving each pair of prolegs forward in turn, the hindmost ones coming last. This can be so rapid with tiger and ermine moth caterpillars that they appear to be running rather than crawling.

The caterpillars of some moths, particularly those of the Geometridae family, only possess the two hindmost pairs of prolegs. In contrast to the 'crawlers', they progress by bending the body into a vertical loop, releasing the prolegs, and then bringing them forward to a position close behind the true legs. These then release their hold so that the body can be extended forward again.

Fit as a flea The jumping power of the flea, although proverbial, was a mystery for many years as it could not be explained in terms of the known properties of muscle–muscle simply could not contract fast enough to supply energy for the flea's remarkable jump. Micro-dissection has shown, however, that the flea has a pad of extremely elastic substance (resilin) inside its thorax. When about to jump, the insect gathers up its hind legs which bend the pad, so storing energy there. Sudden release of the mechanism makes all the stored energy available in a short time, so supplying high-speed power for the jump. However, larger insects, such as locusts and large grasshoppers, do not use resilin in this way but jump by using direct muscular action.

Above: The grasshopper's characteristic jumping motion is made possible by its powerful hind legs. Clearly visible on the large marsh grasshopper (above), these legs are sharply angled so that when they are suddenly straightened the insect is hurled forward.

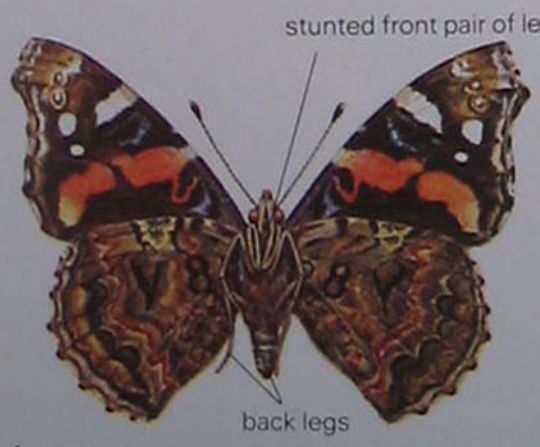
The difference between these two processes is clearly illustrated by comparing the performance of a javelin thrower and an archer. The former throws his spear by direct action of his muscles, while the archer, using a comparable amount of muscle power, draws his bowstring back, so storing energy in the bent bow. Release of the string gives the arrow greater velocity and range than the javelin.

Efficient swimmers A number of insects live in fresh water and are capable swimmers, almost always using their legs for propulsion through the water. Big diving beetles and water boatmen swim by pushing back their hind legs simultaneously on each side like a pair of oars.

Below: Water boatmen swim on their boat-shaped backs using their legs as paddles. Not only efficient swimmers, they can also fly.

Not all aquatic insects live under water–a variety spend their time skating on the surface film. Pond skaters, probably the most widely distributed of the aquatic insects, can be seen moving across the water in forward jerks, their middle legs striking backwards. Whirligig beetles are another familiar sight, using their hind legs to paddle, and keeping their backs above the water level, but undersides and legs below.

The most intriguing surface skimmers are beetles of the genus *Stenus*, which discharge a liquid from their rear to lower the surface tension of the water. The higher water tension in front then draws the insect forward in a smooth and steady glide.



Red admiral
underside

Left: Many butterflies have six normal walking legs, but members of the families Nymphalidae (of which the red admiral shown here is one), Satyridae and Danaiidae have stunted useless front legs.

Right: The pond skater is an insect which lives on the water surface. Its three pairs of legs all serve different purposes: the hind legs act as rudders, the middle legs push the insect through the water and the forelegs catch prey.

Above: A family party of great crested grebes. The adult male and female are very much alike in plumage, although the male is larger, with a heavier bill and larger crest and tippets. In the 19th century these handsome birds were ruthlessly hunted and shot in Britain for their exceptionally soft, silky feathers.

GALLANT GREBES

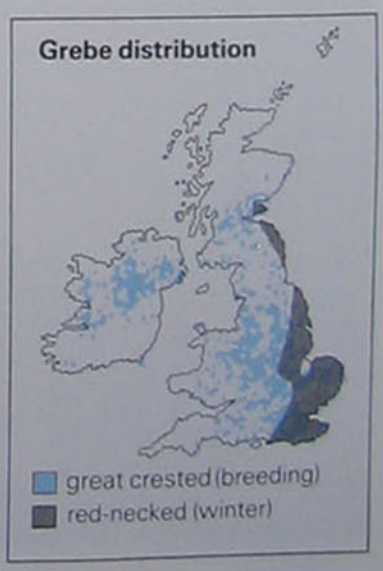
The great crested grebe, the largest member of its family in Britain, is a resident but the species often mistaken for it – the red-necked grebe – is a winter visitor here.

The great crested grebe has a slender body that sits rather low on the water, and a long thin neck that is generally held upright. In the breeding season this handsome water bird is readily identified by its black crest and prominent chestnut and black frills, usually called 'tippets', on either side of its head. The bill is dagger-like and brown, strongly tinged with red, in colour. The upperparts are grey-brown, while the face, neck and underparts are gleaming white. The tippets are shed in the autumn and the great crested grebe in winter is then an altogether duller bird, with a white face, dark crown and a thin white stripe over the eye. In this winter plumage it can sometimes be mistaken for our other large grebe species, the winter-visiting red-necked grebe.

Sad story with a happy ending The great crested grebe is a common breeding bird throughout the lowland areas of Britain and much of Ireland, being found on shallow lakes, reservoirs and gravel pits. It also breeds on some stretches of river. At the time of the last countrywide census in 1975, there were some 6500 pairs nesting in Britain.

This is very different from the bird's breeding status about 100 years ago, when the species was brought to the brink of extinction in this country. Up until about the middle of the last century, great crested grebes bred freely, though in comparatively small numbers, in some 13 counties of southern and central England. At about that time, however, the skins of grebes, with their thick layers of down feathers, became highly fashionable as articles of decorative wear. It is thought that as a result of being hunted for their skins there may have been as few as 32 pairs of great crested grebes left in the whole country.

Many efforts were made to protect the species, and gradually matters improved, with laws passed in the 1870s and 1880s to stop the exploitation. The number of pairs slowly increased, probably helped by immigration from the Continent. In 1931 a census taken throughout Britain revealed a total of just over 1200 pairs, nearly all of them in England and Wales. In the next few decades the num-



Red-necked grebe (*Podiceps griseigena*). Winter visitor found in ones and twos on estuaries and sheltered waters of England/Wales; larger numbers found on Scottish firths. Length 43cm (17in).

ber increased, the grebes at the same time spreading north into Scotland and westwards into Ireland.

Nesting and breeding The nests made by great crested grebes are huge floating platforms of waterweed, anchored to stands of reeds or rushes, or even an overhanging willow branch trailing in the water. The nest often projects only a couple of inches above the surface, although there is usually a much more substantial pile of waterweed lying underneath.

Great crested grebes usually lay three or four whitish eggs. When the incubating bird leaves the nest it flicks a few pieces of weed over the eggs to conceal them from passing predators. Once the attractive, striped young have hatched, the parents take them straight on to the water. The brood often rides on the back of one parent while the other dives for food to bring them.

The young are fed on small insects at first, graduating to smaller and then larger fishes as they grow. After about four weeks, the brood may be split between the two parents, each adult taking some of the chicks to different areas of the nesting lake. After about two and a half months, the young fledge and become independent of their parents.

Elaborate courtship The displays of the great crested grebe, as in other birds, are a form of communication between the male and female. They are used first to establish a strong bond between them, forming a pair that can breed successfully and then be maintained through to copulation and egg-laying. Most of the courtship takes place on the water.

There are four different displays in the great crested grebe's courtship ritual: the 'head-shaking' ceremony, the 'discovery' ceremony, the 'retreat' ceremony and the 'weed' ceremony.

The commonest of the four displays is the head-shaking one. It is performed by both male and female birds, one starting off and the other soon joining in. The crest is raised into two shaggy ear-tufts rising from the back of the head, while the tippets are fanned out to the sides. Each bird slowly swings its head

Above: In winter plumage the red-necked grebe, a winter visitor to Britain, lacks the white eye stripe of the great crested grebe, and has grey areas (not white) on the face and neck, a more extensive black crown, and a yellow (not red) tinged bill. In summer plumage the red-necked grebe's rich chestnut colour on the neck contrasts strongly with a white face and black crown. Very small ear tufts also develop, but are not nearly as obvious as the great crested grebe's crest.

Left: A great crested grebe on its egg-filled nest. The grebe suffers somewhat in very severe winters—a factor which may slow down its rate of increase in this country. In the past it also suffered from organochlorine residues in its fish diet. However, it is probably man's leisure activities—such as windsurfing and water-skiing—that are the main causes of a grebe's failure to breed today. Strong wave action from motor boats can swamp the grebe's nest, and noise and disturbance can drive the bird away altogether.

Great crested grebe (*Podiceps cristatus*). A resident bird on shallow lakes, reservoirs and gravel pits throughout lowland Britain and much of Ireland. Lays 3-4 blotchy white eggs any time from April-July. Length 48cm (19in)—our largest member of the grebe family. Winters on estuaries and on the sea, like the red-necked grebe.

Ceremonies of courtship

The great crested grebe has one of the most elaborate and distinctive courtship displays of any British breeding bird. When displaying, the pair are extremely intent on each other. At first the displays may appear to have little pattern, but close watching reveals that they occur in four parts or phases: the 'head-shaking' ceremony (**1**); the 'discovery' ceremony (**2**); the 'retreat' ceremony (**3**); and the 'weed' ceremony (**4**). In the picture (right) a display has been interrupted by an aggressive intruding male.

from side to side, sometimes with the bill pointing down, sometimes up, or even vertically to the sky. The pace of these movements varies from slow to fast, giving great variation to the character of each performance. Every so often one or other bird suddenly stops and bends its head down to preen among its scapulars (long feathers at the base of the wings). One bout of head-shaking may last for up to three minutes at a time.

In the head-shaking ceremony, both birds perform the same movements, but in the discovery ceremony they perform different movements, although either male or female can do both. If, while you are watching a pair of grebes which are some distance apart, one of them dives, then watch its mate closely. If the birds are indulging in the discovery ceremony, this bird will fluff out all its feathers and raise its wings, crest and tippets. The diving bird will be swimming straight for its mate, often leaving a tell-tale ripple on the surface. Then it abruptly emerges right beside its partner, rearing up on its tail but pointing its head and bill sharply downwards.

The head-shaking ceremony is often ended with the retreat ceremony. One of the pair suddenly ceases head-shaking, lowers itself in the water, and dashes away. At some distance away, it turns and faces its mate again, perhaps to come back and start the whole procedure once more.

The weed ceremony – the climax The climax to the displays is undoubtedly the weed ceremony, which has often been called the penguin-dance ceremony. The birds start by moving together with their necks held bolt upright, crests raised, then first one, followed by the other, dives. They emerge clutching large pieces of soft waterweed in their bills.

At this stage the birds come together to perform the spectacular culmination, the weed-dance. The birds rise up out of the water, breast to breast, paddling vigorously with their feet, at the same time swinging their heads, and loads of weed, from side to side. After as many as 40 such head swings, the water churning under their feet and tails, they subside, drop the weed, and finish quietly with a few shakes of the head. Either the male or the female can initiate any display, but you can tell which is which because in the weed dance his head swings higher than hers.

Below: A male great crested grebe feeding its striped chick with fish. The grebe catches prey under water, submerging gracefully with little more than a ripple. Having located the prey by sight, the grebe pursues and captures it, swimming entirely with its feet and keeping its wings tightly folded to its sides. All but the smallest items of food are brought to the surface and eaten there. Fishes are turned in the bill until they can be swallowed head first.

THE FRESHWATER RIVER THAMES

The non-tidal Thames, from its much-disputed source near Cirencester to Teddington Lock, meanders among water meadows, woodland and grassland, cutting a deep gap through the chalk at Goring. The river enriches the landscapes and habitats it passes through.

Above: The Thames in tranquil mood – the view upstream from near Pangbourne. The wooded hillside on the right belongs to Oxfordshire, the great willowherb-endowed bank on the left to Berkshire.

Opposite: The water meadows on the banks of the Thames are famous for their snake's-head fritillaries. During May, thousands of them can be seen in Magdalen Meadow in the grounds of Magdalen College, Oxford.

The source of the River Thames is a spring in a clump of trees at Trewsbury Mead, about 5.6km (3½ miles) south-west of Cirencester in Gloucestershire. It can be reached by walking north from the old Roman road, the Fosse Way – now the A433 – although it is on private land and there is no public footpath. The spring is marked on the Ordnance Survey map as 'Thames Head: the source of the River Thames' – and the Thames Water Authority recognise this site as the official source. However, the source of the Thames has often been disputed. Some claim that it is at Seven Springs, about 4.8km (3 miles) south of Cheltenham.

In summer there is seldom any water flowing from the spring; the Thames is a winterbourne here and flows on the surface only during the winter months. In summer the spring and watercourse may be completely dry down to Somerford Keynes or further. Except for the dry saucer of stones marking the spring, the source of the River Thames is ploughed up and sown with rye grass – the modern agricultural replacement for the traditional meadow or pasture which once existed here.

Rising in the Cotswolds, the Thames flows eastwards towards Oxford, starting as a clear, rippling, infant stream, then running swift and shallow with no weirs to impede its progress between Cricklade and St John's Lock

Above: The source of the Thames–Trewsbury Mead near Cirencester. A statue of Old Father Thames once stood here, but it was removed for safety and now stands beside the river at St John's Lock, Lechlade. There is confusion over the name of the stream flowing from Trewsbury. From its source to its junction with its tributary, the Thame, some distance below Oxford, the ancient name for this part of the river is the Isis. It only becomes the Thames after joining the Thame.

(Lechlade). At Oxford it bends sharply to flow southwards to Abingdon and onwards to the Goring Gap where it flows between the thickly wooded chalk Chilterns and Berkshire Downs; the river here becomes broader and slower moving–and also muddier. At Eton and Windsor it flows south-east, but turns at Weybridge to flow east again through London to the sea.

On its way the Thames passes through dramatically changing landscapes–water meadows, agricultural grassland, arable crops, wooded hillsides and built-up urban areas. The flora and fauna of all these different habitats are quite distinct–contributing much to the diversity and richness of this greatest of English rivers.

Riverside grasslands The characteristic habitats bordering the Thames from source to estuary are water meadows and pastures. Meadows cut for hay, and pastures grazed by livestock, have been the traditional type of farming in the Thames Valley for centuries. Although these grasslands are artificial habitats, created by man, they are full of native species of grasses and herbs. If left unmanaged, they would eventually succeed to deciduous woodland, dominated by oak, alder or willow according to the differing environmental conditions.

However, there is not much chance of this today. Most of the grasslands have been destroyed by urbanisation and modern intensive agriculture. Drainage, ploughing, herbicides, fertilisers and agricultural grass seed mixtures have converted these areas into high yielding grasslands or arable crop fields. Trewsbury Mead is no exception.

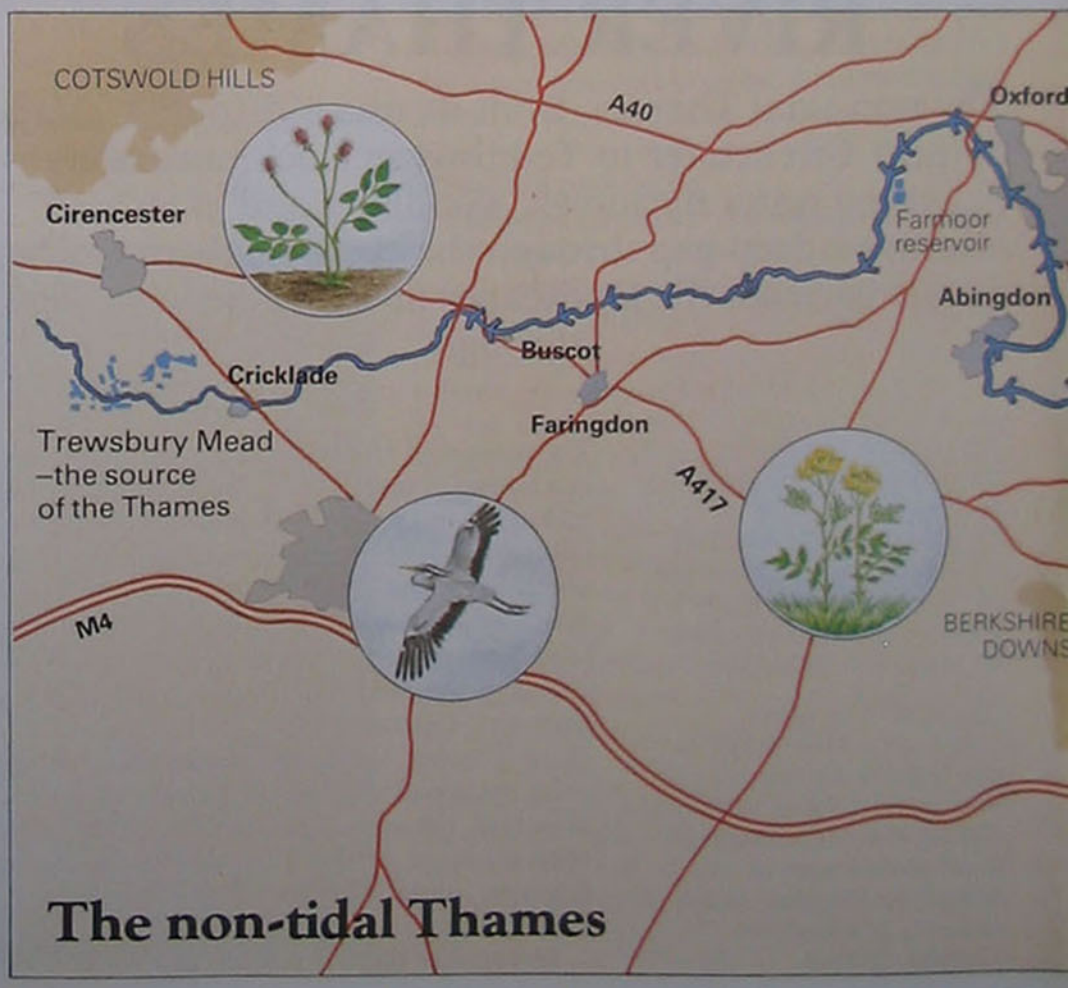
Nevertheless, a few ancient water meadows and pastures still exist, particularly from the source of the river down to Oxford and just below. These meadows and pastures, situated on the alluvial soils of the Thames flood plain, are some of Britain's richest grasslands in terms of number of species growing on them. Typically, they are flooded in winter by the increased amount of water carried by the river and so are suitable for grazing or cutting only in the summer. Once drained, then the grazing or cutting season can be extended and the diversity of flora reduced.

Grassland flowers A typical plant species in the meadows and pastures of the upper Thames is the beautiful snake's-head fritillary. It has declined dramatically as a result of drainage and increased grazing, and picking, particularly for sale, has also contributed. Efforts by the Berkshire, Buckinghamshire and Oxfordshire Naturalists' Trust and the Gloucestershire Trust for Nature Conservation have resulted in the traditional management of some meadows and pastures being retained for the conservation of this and other species in these wetland areas.

In Britain orchids are rare in any plant community, but in the wet grasslands bordering the Thames the early marsh orchid is a fairly common species, green winged orchid is local (but abundant where it does occur), and burnt orchid is uncommon. Adder's-tongue fern is common in some riverside grasslands.

Rare plant species are not the only attraction of riverside grasslands. Many common species contribute to their beauty. Whole fields coloured golden with dandelions or buttercups are typical in June, and among these dominant flowers are patches of common species which provide exciting splashes of colour. These include the brilliant pink ragged robin, meadowsweet, purple-red great burnet and shuddering quaking grass.

Chalk woodland The Thames rises in the limestone rocks of the Cotswolds and flows



The non-tidal Thames

through deposits of gravels, sands and clays to the Goring Gap where, at some time in the past, it has cut a path through the chalk hills, dividing the Chilterns from the Berkshire Downs. It then flows onwards through more gravels and sands to the estuary.

From Goring to Maidenhead the river passes by steep chalk hills covered with grassland and woodland (mainly beech). Chalk grassland is as rich in species and as colourful as the wet meadows. Beech trees in the woodland cast a dense shade because of the overlapping arrangement of their leaves. The lack of light means that very few plants are able to grow beneath them. However, bird's nest orchid and many toadstools are well-adapted to this dim light. They are saprophytes, digesting the leaf litter for food and so unlike green plants as they require no light.

Wetland birds The extraction of sand and gravel throughout much of the Thames Valley has produced numerous water-filled pits. The construction of reservoirs, such as the ones at Staines and Farmoor (near Oxford) has also increased the area of fresh water. Gravel pits and reservoirs provide valuable feeding, nesting and roosting sites for a variety of birds, and their construction has certainly been responsible for the increase in numbers of the great crested grebe. The newly dug edges of the gravel pits provide breeding sites for the little ringed plover, which first bred in Oxfordshire in 1947, while the vertical cliffs of the pits are often riddled with the nest holes of sand martins. The increase in numbers of Canada geese is probably also related to the proliferation of gravel pits, which they use for breeding.

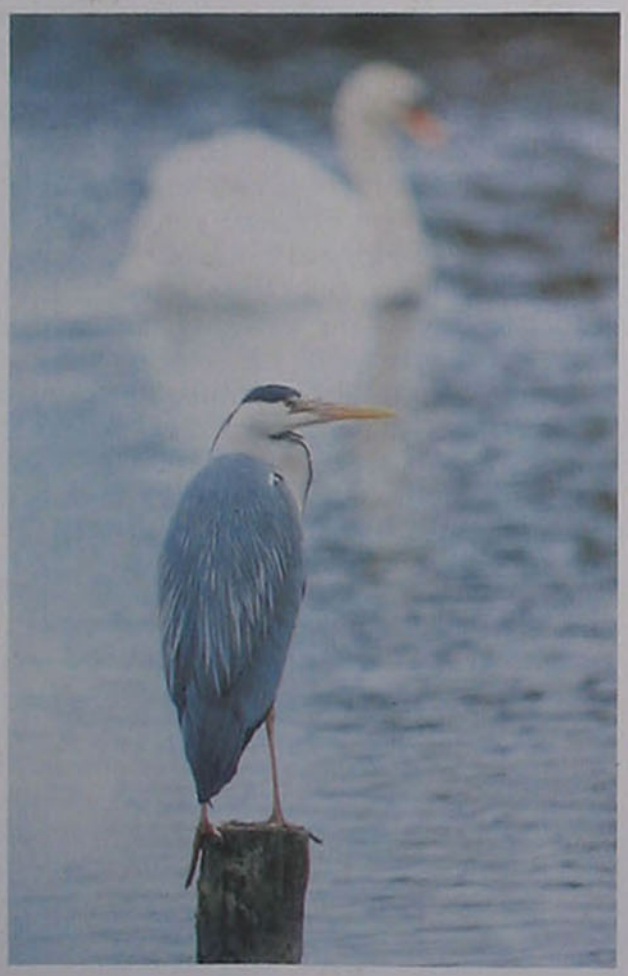
Above: The arrowhead is a water plant you may well find in the quieter, shallower backwaters of the Thames. It is named for the distinctive shape of its leaves.
Much of the land along the river has been turned over to arable crops—mainly wheat and barley—and the grassland has been sown with a mixture of about five grass species and clovers. The traditional meadows are recognisable by their wealth of wild flower species.

This increase in gravel pits and reservoirs has helped to make up for the loss of marshes and shallow water due to drainage operations. Ducks which favoured these areas now make use of the pits: mallard, tufted duck, wigeon, teal, pochard and shoveler all breed on them, while winter visitors include goldeneye and, more rarely, the long-tailed duck.

All these ducks, and others as well, can be seen regularly on the waters of the Thames Valley—but because of the constant flow of boat traffic from spring onwards through the summer, they prefer to nest away from the busier stretches of the river where there is less chance of disturbance to the eggs and chicks. The gravel pits are, of course, ideal as breed-

From its source among the limestone Cotswolds, through the flat water meadows and on past the beech woodlands of the chalky Chilterns and Berkshire Downs, the Thames takes a slow, meandering course. There are many locks along its length—and a vast number of boats that negotiate them every year! Anglers, tourists and day-trippers also abound, but there's plenty of wildlife species still to be seen—among them the great burnet, heron, meadowsweet, dragonfly, pike, quaking grass and goldeneye duck shown here.

Above: The Loddon lily is a very rare plant species which is only native along the River Thames and the River Shannon. Its name reflects its association with the River Loddon—a tributary of the Thames. Another name for this attractive species is the 'summer snowflake'. It flowers in April and May and reaches 60cm (2ft) in height.



Left: A solitary heron hunched on a post. Herons and kingfishers are still common along the Thames and its tributaries. Heronries have declined in the Thames Valley, but a thriving one can be seen in Buscot Park near Faringdon. During the last 30 years mute swans have shown a rapid decline in numbers, but among the waders redshank, curlew and snipe still breed in the wet meadows and pastures.

ing sites.

Insects During the summer, dragonflies, damselflies, mayflies and caddisflies are frequently seen on the wing along the river banks. They all spend their larval stages underwater. In the upper reaches of the Thames in June scores of damselfly nymphs crawl up the sedges and emerge as brilliant blue adults. In still pools out of the way of the rippling current, whirligig beetles and pond skaters run on the water surface with their specially adapted legs.

Thames fishes The Thames and its tributaries offer an excellent variety of fishing. Evidence of its popularity with anglers is provided by the number of rod licences issued by the Thames Water Authority. During the year April 1981-March 1982, for example, nearly 130,000 annual licences, 49,000 fifteen-day licences and 40,000 junior licences were issued.

From Lechlade to Teddington Lock–the navigable part of the section of the Thames considered here–anglers are likely to catch such fishes as bream, gudgeon, pike, chub, perch, and roach. The faster-flowing stretches of the river harbour barbel, a bottom-dwelling fish, while in a few places the tench–also a bottom-dweller–may be found. Shoals of bleak and dace can be discovered feeding near the surface of the water.

Brown trout are abundant in the Thames above Lechlade, where the river is narrower and faster-flowing, these fishes favouring the limestone and chalk tributaries of the river, and also the weir pools between Lechlade and Teddington.

The Thames Water Authority has done much to clear pollution of the Thames, so the river is much cleaner now than it was 100 years ago. As the water quality continues to improve, we may even see salmon migrating up the Thames. The Thames Water Authority are experimenting with the placing of salmon eggs and fry in some of the tributaries of the Upper Thames and salmon are being caught by anglers–good evidence that these salmon are thriving and an indication of the high quality of water in the Upper Thames catchment area.

The plight of the mute swan

Mute swans, like most birds, eat sand and gravel which lodges in their gizzards and helps to grind up plant food. Unfortunately, swans also pick up lead weights lost by anglers. The soft lead is ground up in the gizzard and then absorbed into the swan's tissues. If enough weights are eaten, the swan will die. Death from lead poisoning is a long, slow process. Swans suffering from lead poisoning have a kink at the base of the neck (right), whereas healthy swans are able to hold their heads in an upright position. The lead affects the nervous and muscular systems so that the swans become lethargic and cease to eat because the gizzard muscles no longer function.

The worst affected rivers are the Avon, Trent and Thames. The solution to the problem lies in the manufacture of weights in non-toxic materials such as stainless steel. This has been initiated in the USA and is urged here by the NCC. Certainly some measures are necessary: between 1979 and 1981 about 75% of dead swans from the Thames died of lead poisoning.

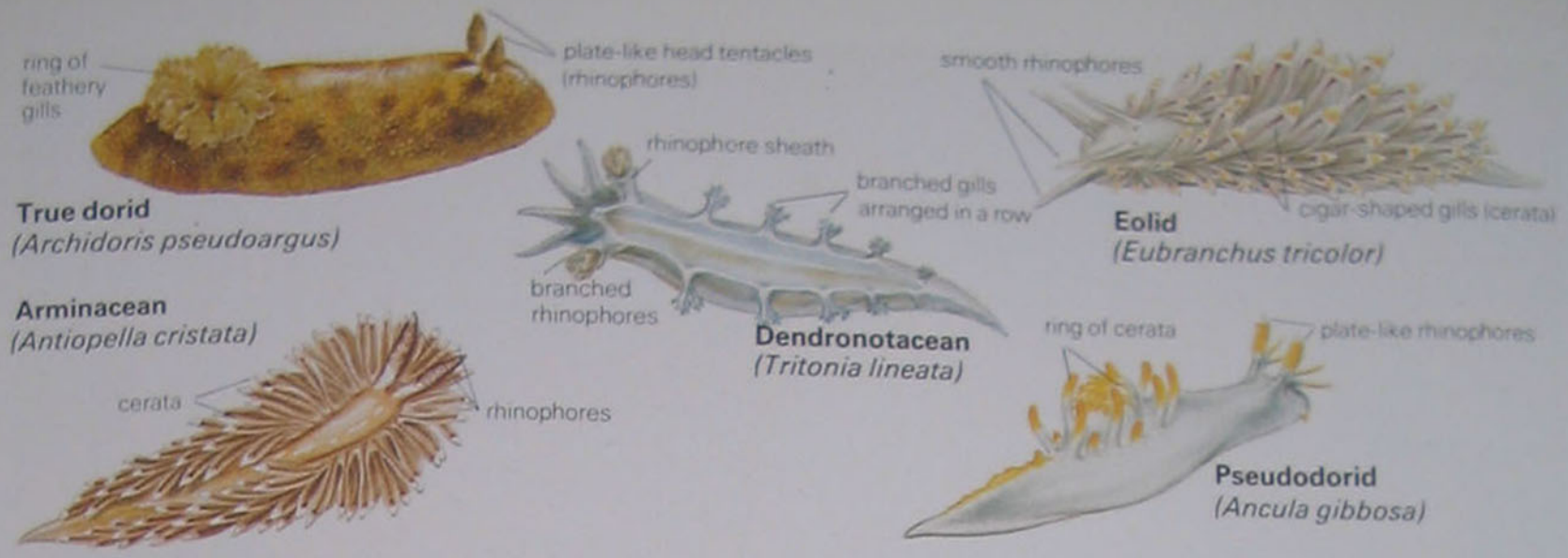
Above: *Facelina auriculata*, seen here thrashing its gills (known as cerata) in a defensive display. Intending predators would do well to treat this nudibranch with respect for, when it eats a sea-anemone, it stores the anemone's toxic stinging threads in the tips of its cerata. The nudibranch then uses these stinging threads to ward off potential enemies, though they clearly have little effect against other nudibranchs.

NUDIBRANCHS: BRIGHT COLOURED SEA SLUGS

Among the most colourful creatures found around our shores is a group of small shell-less molluscs called nudibranchs. More often known as sea slugs after their general shape, they inhabit the sea-bed, where they graze on sedentary animals such as sponges and sea-anemones.

Commonly known as sea slugs, nudibranchs (the word is pronounced with a hard 'k' at the end) are marine molluscs related to the limpets, whelks and winkles, as well as to garden snails and slugs. Most species are small, ranging from 1-5cm ($\frac{1}{2}$-2in) but a few species grow larger, up to 15cm (6in). They are carnivorous, grazing on small animals attached to the sea-bed. Like other gastropods, nudibranchs crawl about on a foot but they differ in that they lack a shell. In fact, this feature is the origin of the name nudibranch, for it means naked gills. (Shelled gastropods protect their gills inside their shells.)

Four kinds of nudibranch Nudibranchs can be separated into four groups, although the



Above: Each genus of nudibranch produces its own characteristic eggs. These are from *Archidoris,* a genus that spends most of the year in deep water.

Below: Two specimens of *Dendronotus frondosus* crawling over vegetation. This species is 5cm (2in) long and has branched gills.

evolutionary relationships between them are not known. The best-known nudibranchs are the dorids. These all have a ring of feathery gills in the middle of their backs. Dorids, in common with all other nudibranchs, have two erect head tentacles called rhinophores. These are the main sense organs, and they detect smell or taste in the water with great efficiency. In the dorids these rhinophores are shaped to look like a stack of plates. This gives a very large surface area and increases their sensitivity. The eyes are very small, however, and can only distinguish between light and dark.

The second group, the dendronotaceans, have gills arranged in a row down each side of their backs. These may be conical with rounded tips, or branched. The rhinophores of nudibranchs in this group are surrounded by a cup-like sheath, into which they can be withdrawn for protection.

The eolid nudibranchs have cigar-shaped gills called cerata arranged in vertical rows or bunches down the sides of the body. Each group of gills surrounds a central digestive core. The rhinophores are usually smooth, but may bear a series of plates like those of the dorids.

The last group, the arminaceans, is a very mixed group including all the species which do not fit into the other groups. *Hero* is like a dendronotacean with feathery gills, but its rhinophores lack sheaths. *Antiopella* is like an eolid in having cerata, but is totally different in its anatomy. *Armina* is a flattened burrowing form with gills set in a groove around the sides of the body.

Reproduction Nudibranchs are all hermaphrodites, that is they possess both male and female sex organs. This means that any individual can mate with any other individual, thus allowing every animal to produce eggs and so giving the maximum egg output for the population as a whole. The reproductive organs are situated on the right-hand side of the body and, during mating, the animals pair in a characteristic position, head to tail with their right sides together. Each individual passes sperm to the other, and these are stored internally until the animal lays its eggs.

Egg-laying is a lengthy process, taking several hours. The animal selects a suitable spot, then moves slowly around, usually in circles, depositing a spiral coil of eggs in a neat and characteristic pattern. The egg coil of each species is slightly different, with greater differences between genera, and it is possible to identify many species just from their eggs.

The eggs hatch into tiny larvae which usually swim up into the plankton and drift

with the currents for days or even weeks. When the larvae are ready to settle, they sink to the sea-bed and move about searching for food. If the correct food is found the larvae metamorphose into small nudibranchs, which begin to feed and grow.

There is enormous wastage at this stage of the life-cycle as only a minute proportion of the larvae will settle near any suitable food. This requires the production of tens of thousands of eggs by those that do survive, to ensure that the next generation will be successful.

Fussy feeders Nudibranchs are very specialised in their diets. Most feed on food that many other animals find inedible. Dorid nudibranchs feed mainly on sponges and bryozoans. *Jorunna tomentosa* feeds on sponges of the genus *Haliclona*, while *Rostanga rubra* appears to eat only the red sponge *Ophilitaspongia seriata*.

The dendronotaceans are no less specialised in their diets, feeding mostly on coelenterates such as hydroids and soft corals. *Tritonia odhneri* feeds on the sea-fan *Eunicella verrucosa*, on which it is superbly camouflaged. The many species of *Doto* eat only one or two species of hydroids.

This close dependence upon a particular food is almost like a host-parasite relationship. Furthermore, it is believed that because the prey is so well protected – by poisonous chemicals in the case of sponges, or by powerful stinging cells in the case of hydroids – the nudibranch must have a specific antidote in order to eat the food.

Eolid nudibranchs exhibit yet another unusual feat connected with their eating habits. They feed on sea-anemones and hydroids, which have stinging cells. Instead of digesting these stinging cells the nudibranch passes them through its gut and stores them in small sacs called cnidosacs at the tip of each of the cerata. The cerata may thus resemble the tentacles of sea-anemones, and any fish that doubts the resemblance and takes a bite of the nudibranch will be stung by the stinging cells.

Arminid nudibranchs feed on a variety of items: for example, *Armina* feeds on sea-pens, which are coelenterates, and *Antiopella cristata* feeds on the bryozoan *Bugula*, but has cerata just like an eolid. These cerata have no cnidosacs, and indeed *Bugula* has no stinging cells. It is possible that the cerata of *Antiopella* are really mimicking those of an eolid, but it is also likely that they produce noxious tasting chemicals.

Some nudibranchs have developed very specialised diets. *Onchidoris bilamellata*, a dorid, feeds on barnacles, while its closest relatives all eat bryozoans. Members of the genus *Favorinus* eat the eggs of other nudibranchs, whereas most eolids eat hydroids. *Calma glaucoides*, another unusual eolid, eats fish eggs. The yolk of these eggs is such a pure form of food that *Calma* has no anus – it can digest its food entirely, leaving no waste matter at all.

Many nudibranchs inhabit the lower shore and can be discovered by turning over rocks and searching in pools. The main habitat for nudibranchs is below low tide, however, where they live among the hydroids and bryozoans which are abundant in rocky places. Here they have been much studied by divers, though new species are still being discovered around the British Isles. As SCUBA diving becomes easier and more accessible to marine scientists, more species – and more information on the life histories of these strange creatures of the sea – will no doubt come to light.

Above: Many nudibranchs display bright colours, possibly in an attempt to deter predators. Shown here is *Antiopella cristata* from Lundy Island.

Below: *Tritonia plebia*, feeding on the sea-fan, a species of soft coral. Both the sea slug and its eggs, which can be seen coiled around the coral, are superbly camouflaged. The bulbous structures near the lower end – the head end – of *Tritonia* are its tentacles.

A PAIR OF GODWITS

Godwits – large waders with long legs and beaks – frequent coastal mudflats in winter. Only one species breeds here, the black-tailed godwit, which nests in damp grassland.

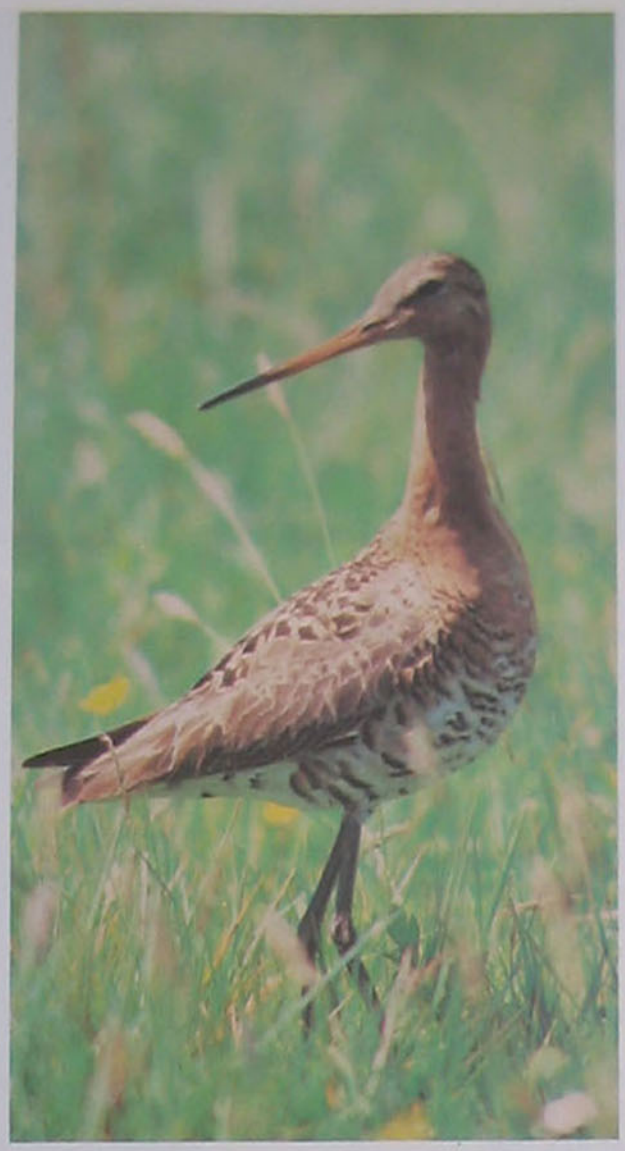
In Britain and Ireland we have two species of godwits: the black-tailed godwit, which is both a summer and winter visitor, and the bar-tailed godwit, which is only a winter visitor. While the difference in their tail colours is accurately described by their English names, these features are not the best distinguishing marks, especially as the tails are mostly hidden by the wings except in flight. With feeding godwits, look at the relative proportions of the legs, beak and body, and at the general coloration. With flying godwits, check to see whether or not there is a white wing bar.

The black-tail This is the taller of the two species: it has longer legs which trail well

Below: A male black-tailed godwit settles down to incubate its eggs. It has fine chestnut and black breeding plumage, and an elegant profile. Godwits are much bigger than other waders such as dunlins and redshanks, and you can easily distinguish them from curlews by their straight beaks (curlews have curved beaks). You can tell them from oystercatchers most easily by their generally brown or reddish plumage; oystercatchers' plumage being black and white.

Right: A black-tailed godwit looking round as it approaches its nest. It is a tall bird – the unmown grass in this field only reaches the height of its knees.

Below: The black-tailed godwit breeds in the Ouse Washes and other lowland areas, but winters mainly on estuaries. The Channel coast areas are frequented by Continental breeding birds, while the Icelandic birds winter in other areas.



behind its tail in flight, and a remarkable 11cm (4½in) long beak. Its winter plumage is rather plain, being mostly brown above and white below, but in summer its head, neck and breast turn a beautiful chestnut colour. In flight, in both winter and summer plumage, the black-tailed godwit displays one of the most conspicuous white wing bars of all our waders, and this, coupled with its large size and black tail with a white base, permits positive identification at a considerable distance.

The bar-tail For the size of its body, the bar-tailed godwit's legs seem rather short, and the feet only just project behind the tail in flight. Its beak is about 9cm (3½in) long, and is slightly upturned. In winter the bar-tailed is usually paler than the black-tailed godwit and often looks rather grey against the dark brown of its muddy feeding areas. The white and brown barred tail is not conspicuous, and when the birds are on the ground it may not be seen at all.

Although this species does not breed in Britain or Ireland, some bar-tailed godwits moult into and out of summer plumage on certain of our estuaries – the Wash, Ribble and Morecambe Bay estuaries being particularly favoured. In the summer, the head and underparts are even more brightly coloured than those of the black-tailed godwit, and the chestnut colour extends right back to the under-tail coverts. Moulting birds have a rather spotty appearance.

Above: The bar-tailed godwit winters on favoured estuaries.

Right: Having fed as they followed the tide out, these bar-tailed godwits have plenty of time at low tide for preening and bathing. Bar-tails tend to prefer sandier estuaries, black-tails muddier ones. When the tide rises, the godwits fly in small groups to habitual roosting sites on islands, marshes, beaches, even meadows or playing fields.

In flight, the bar-tailed godwit's large white rump becomes visible, the white area extending forward to a point about half-way up its back. The tail bars are visible if rather pale, and there is no white wing bar.

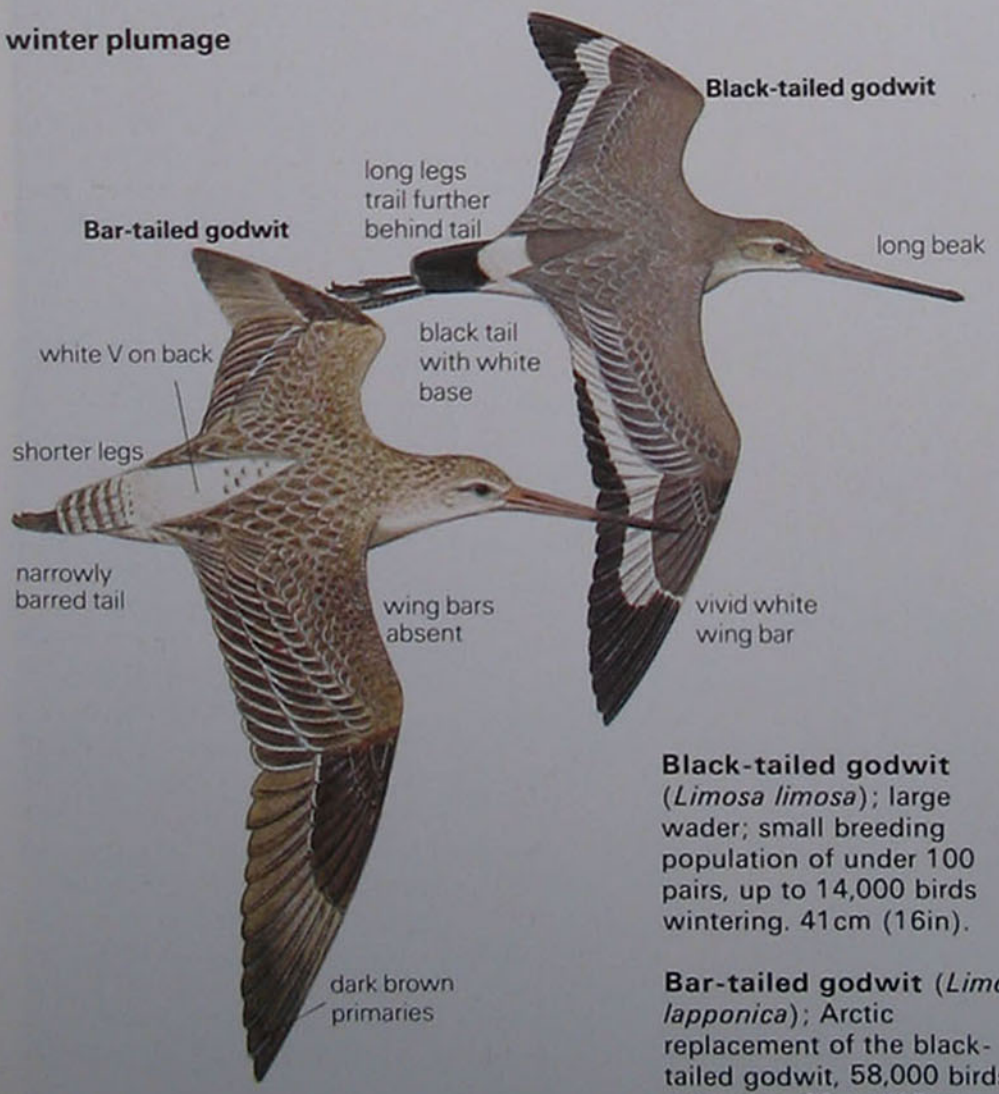
Breeding of the black-tail The black-tailed godwits of Britain and Ireland belong to two separate sub-species, each with its own geographical area. One subspecies is centred east of us, in Continental Europe, and the other, distinguished by its shorter beak and redder plumage, to the north-west of us, in Iceland. Both groups nest in Britain and Ireland, but neither is at all common. Birds of the Continental group are known to breed regularly in a few lowland areas in south-east England, and the Icelandic group is represented by a few breeding pairs on remote moorland sites in Scotland.

The black-tailed godwits arrive on their breeding grounds in spring and soon establish well-defined territories. At this time they are vocal and conspicuous, displaying on the wing and from posts or on the ground, and uttering their piping alarm calls and song. The displays are designed to show off the bright breeding colours: the breast is puffed out, the tail fanned, and the wings lifted high.

The nest is a pad of dead grass or leaves, usually in a hollow on a tussock or up on the bank of a dyke. The female lays four well-camouflaged eggs and is helped by her mate with the 24-day incubation period. The chicks feed themselves within hours of hatching, but are protected by their parents until they can fly, at about four weeks old.

Above: A black-tailed godwit chick awaits the feeding parent in its nest. This is typically situated in short grass: long damp grass can be highly dangerous for young chicks, since their fluffy down is easily drenched so that they chill and die. Traditional use of damp meadows for grazing used to keep the grass short and provide a habitat for black-tailed godwits.

Right: A juvenile male bar-tailed godwit, preening at low tide.



Black-tailed godwit (*Limosa limosa*); large wader; small breeding population of under 100 pairs, up to 14,000 birds wintering. 41cm (16in).

Bar-tailed godwit (*Limosa lapponica*); Arctic replacement of the black-tailed godwit, 58,000 birds wintering. 38cm (15in).

Up until the 19th century, black-tailed godwits were common British breeders. However, egg-collecting and shooting, coupled with changes in agricultural practices, caused them to become virtually extinct in Britain and Ireland by about 1830. For more than 100 years breeding attempts were few and far between, and only in the last 30 years have the black-tailed godwits regained a foothold here.

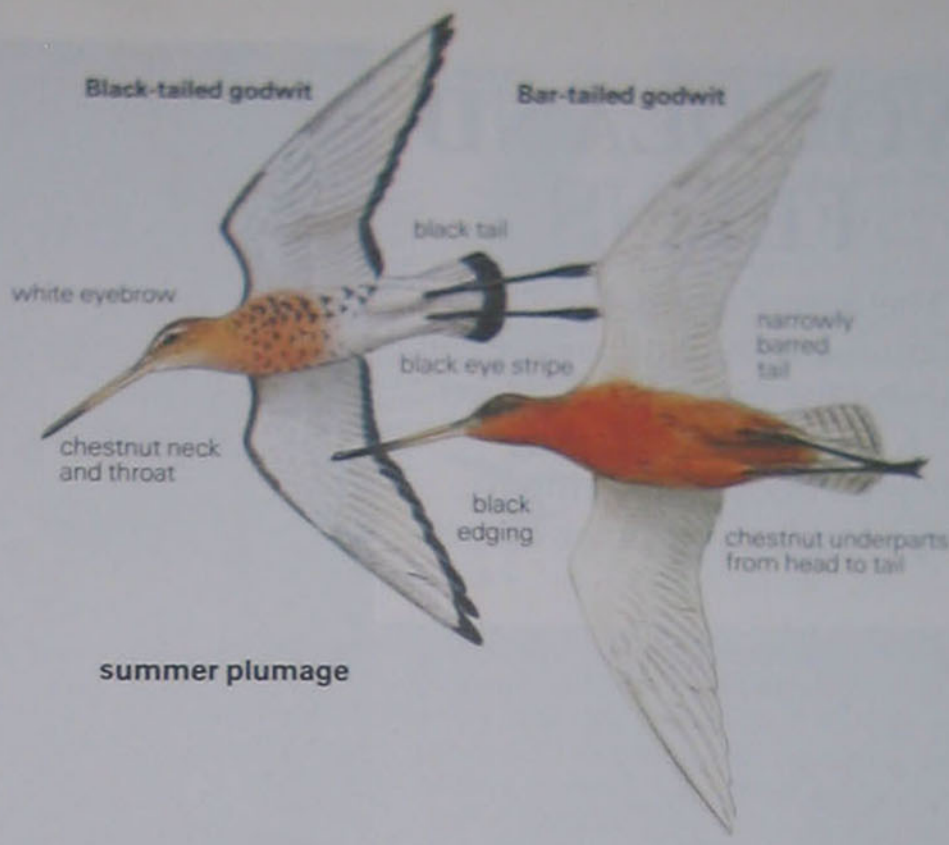
Water meadow life Their favourite breeding habitat is the water meadow. These fields are flooded by nearby rivers in winter, grazed in spring and cut for hay late in the summer. The godwits arrive while the floods are receding, rear their families while the grass is short, and leave before the hay is cut. Unfortunately, most of our water meadows–or washes as they are sometimes called–have been drained to make way for modern intensive farming.

In view of these habitat requirements, the main breeding site of our present black-tailed godwit population–the Ouse Washes of East Anglia–is perhaps predictable. Here the River Ouse still floods its banks each winter, thus perpetuating one of the last remaining areas suitable for black-tailed godwits. The first pair to nest there, in 1952, was unsuccessful, but four pairs returned the following year. Slowly and steadily the newly founded colony expanded, until in 1972 as many as 65 pairs

bred and over 100 chicks were reared. Regular breeding now occurs at several other sites in Britain, although since 1972 the total British population has stabilised, or even decreased slightly. The most recent estimate was of a maximum of 77 pairs in 1980.

The Ouse Washes now form a nature reserve, and the black-tailed godwit is specially protected by law, so we should have breeding godwits for some years to come. However, their future is only partly under our control. They have, for example, proved vulnerable to late spring floods, since the breeding sites are very flat and large areas can be covered in water overnight, flooding nests and leaving the chicks no chance to escape. For this very reason, only one pair was successful on the Ouse Washes reserve in 1981, though some pairs did manage to lay replacement clutches in adjacent farmland.

Migratory movements Bar-tailed godwits breed in Arctic Scandinavia, Russia and Alaska. Many of those in the western part of this massive range winter in Europe and Africa. They arrive in Britain and Ireland from July onwards, eventually reaching a peak of about 58,000 in January–a staggering 65% of those in Europe. There is no doubt that our estuaries are of international importance to bar-tailed godwits. They start to return in February and March, some flying as far as 8000km (5000 miles) into Russia. Later, those which have wintered in Africa can be seen migrating along the English Channel, and up to 4000 have been counted in one day passing prominent headlands. Very few stay behind in the coastal region of southern England, those that do being non-breeding first-year birds, which remain in winter plumage.



Below: A bar-tailed godwit in winter plumage. The tail bars are just visible, but the bird is better distinguished from the black-tail by its shorter bill and legs. The upperparts are also more streaked.

European black-tailed godwits, including the British birds, winter south of the Sahara in West Africa. The Icelandic birds winter in Britain and Ireland and southwards to North Africa. About 4000 winter in England and Wales, and 10,000 in Ireland. More are seen at migration times, particularly in autumn, when a total of 16,500 may be present.

Changing diet As might be expected, godwits' diets change with the seasons. Those nesting on moorland may initially feed on berries, though later, and in lowland areas, freshwater and land invertebrates are eaten. Beetles, caterpillars, worms and molluscs are particularly favoured. The winter diet is primarily of coastal and marine animals, such as worms and shellfish. With their long beaks, godwits are ideally equipped for dragging lugworms from their burrows. They hunt partly by sight and partly by touch–driving the beak deep into the mud and feeling with the soft and slightly pliable tip for food. When feeding in water, godwits occasionally spread their wings out like an umbrella to reduce reflections and help them to catch small fish.

When the creeks, channels and flats are covered by the sea at high tide, the godwits fly in small groups to habitual roosting sites on islands, marshes, beaches and elsewhere. Sometimes they fly in V formation, and often they tumble playfully from the sky as though temporarily out of control, but 'brake' skilfully before joining those already settled. The timing of their movements is thus determined by the tide.

WOODLAND FERNS

The damp, shady floor of deciduous woodland is an ideal habitat for many ferns. Hard to spot in winter, their fronds uncurl in spring to form a feathery summer carpet.

Above: Mature broad-leaved woodland can contain an almost tropically rich fern flora. Ferns such as this male fern are seen at their best in mid-summer, when their fronds are fully expanded, giving them the shape of a basket.

Left: The distinctive fronds of the hart's-tongue fern (*Phyllitis scolopendrium*) have striking, long, straight sori on their undersides.

Woodland ferns die back in the winter, their dead fronds protecting the crown (or growing point) of each plant during the most severe weather. In late spring, the curled young fronds–known as croziers–begin to appear, different species unfurling at different times.

Typical woodland species include the buckler, shield and male ferns, and the delicate lady fern. They are seen at their best in mid-summer, when their fronds are fully expanded. Looking rather like large green shuttlecocks, the plants form a feathery carpet on the woodland floor.

It is at this time of year that the contrast is most apparent between the abundance of these ferns in woodland–where they may form a lush, almost tropical, cover–and their scarcity in the surrounding fields and moorland. However, although typical of woods, these ferns are also found in similar, favourable conditions elsewhere–in damp, shady hedgerows for example, or on open, rocky hillsides or even on the coast. Bracken is a marked exception. A very invasive species, it is found not only along woodland edges and in clearings, but also spreading over the surrounding pastureland as well.

Young plantations of conifers or broad-leaved trees are rarely carpeted with ferns, the conditions of light and moisture under the tree canopy being more suitable for grasses and other herbs. Mature conifer woods generally have only scanty undergrowth–or none at all–but where the trees are some distance apart, ferns are able to establish themselves.

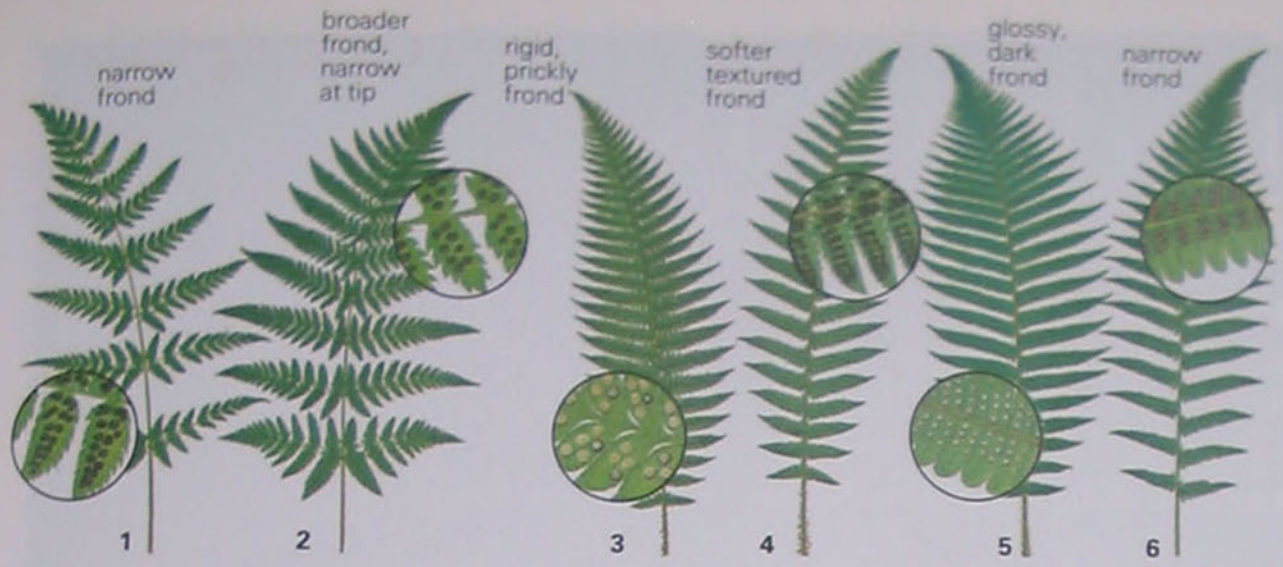
Growth patterns The fronds of such woodland ferns as the male, scaly male, broad buckler, hard shield and soft shield ferns are arranged in a whorl on an erect stem. The lady fern also has an erect stem which may grow quite tall and look like a miniature tree trunk. It is the native species that comes close to the tropical tree ferns in appearance. In contrast, the stem of the narrow buckler fern is horizontal and only a few fronds arise from it at intervals.

The size and appearance of the fronds can vary considerably between one individual and another within any one species. About 50 varieties of the soft shield fern, 70 of the lady fern and as many as 150 of the hart's-tongue fern have been identified. The varieties cover a remarkable range of form. The proportions of the pinnae or of the whole frond may be different, for example, and sometimes this produces a very feathery, dissected appearance. The fronds may even be branched and their margins incised or wavy. The lady fern exhibits a particularly striking variation in the colour of the frond stalk, which may be anything from pale green to dark brown, or even a bright reddish-brown.

Names and identification The indusium of a fern is the papery material that normally covers the groups of spore capsules (sori) seen on the underside of fern fronds. Its shape and

Fern collecting

Many fern species, being very variable in form, were of great interest to the Victorian fern collectors, although several suffered from over-collection. Some 19th century fern books were illustrated by the process of 'nature printing' where fronds coated with ink were pressed on to the page. Large numbers of the delicate fronds were required as each could be used only a few times.



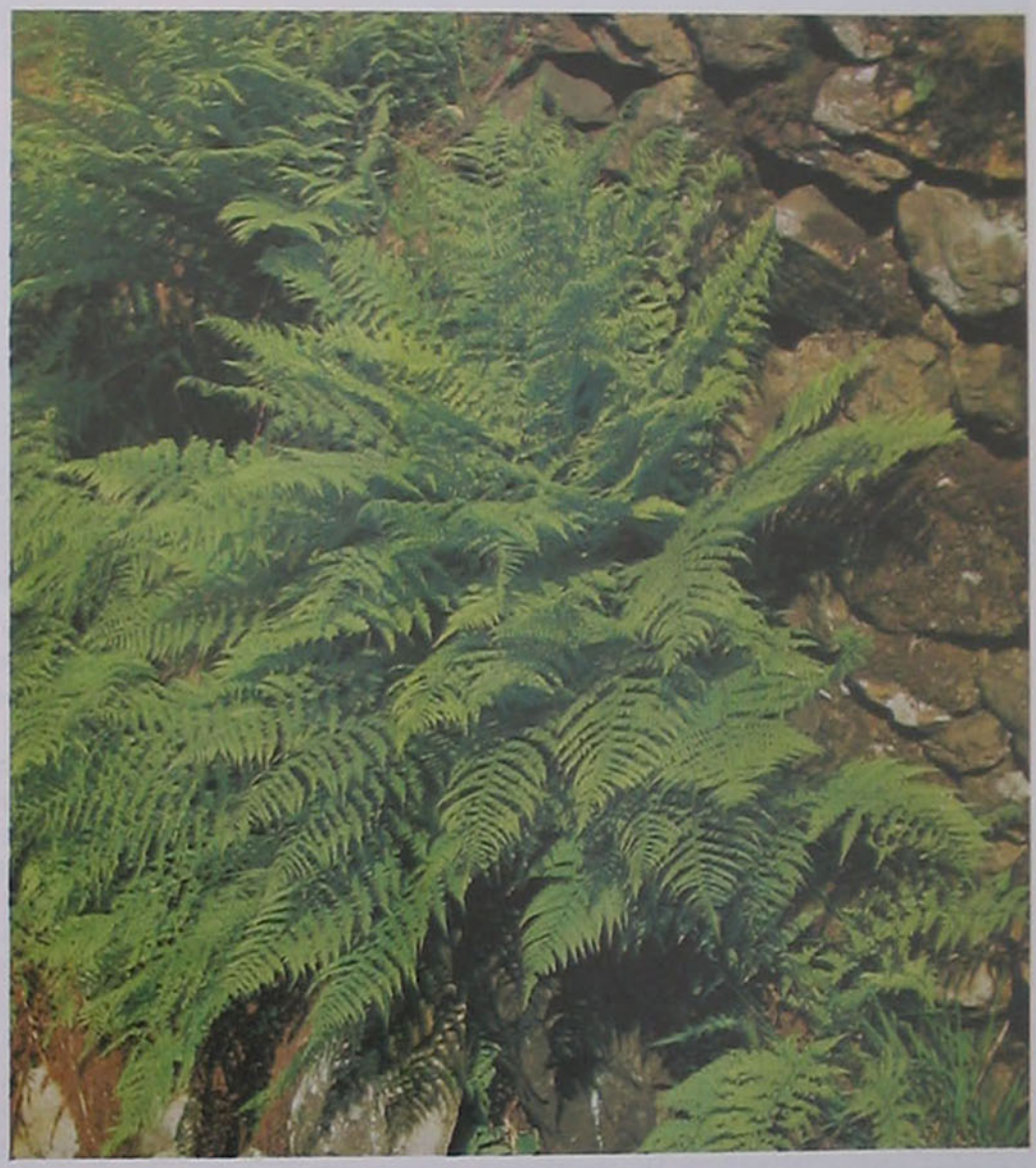
Fern identification
1. Narrow buckler fern (*Dryopteris carthusiana*).
2. Broad buckler fern (*Dryopteris austriaca*).
3. Hard shield fern (*Polystichum aculeatum*).
4. Soft shield fern (*Polystichum setiferum*).
5. Scaly male fern (*Dryopteris affinis*).
6. Male fern (*Dryopteris filix-mas*).
The details in circles show the sori on the underside of the fronds.

location is important not only in the classification and identification of ferns, but also in the origin of common names. The indusium's resemblance to a shield in *Polystichum* species has led to the name 'shield ferns', while the buckler ferns are also named from the shield-shaped indusium, a buckler being a small parrying shield. This name has been used as part of the common name for most *Dryopteris* species since about 1860. However, the two largest *Dryopteris* species in the British Isles are known as the male fern and scaly male fern. This allusion to masculinity conveys the way in which their robust appearance contrasts with the relatively delicate lady fern.

Differences in shape and texture are also indicated by common names, as seen, for example, in the soft shield and broad buckler ferns. Both shape and frond texture are reflected in the name of the evergreen hart's-tongue fern. Local folk names are given to ferns in different parts of the country, and so hart's tongue is also known as buttonholes (from the appearance of the young sori), seaweed fern, burntweed, Christ's hair, long leaf, horse-tongue and lamb-tongue.

Fern habitats Although woodland ferns are found throughout the British Isles, they may be locally rare or very abundant. For example, the hard shield fern is generally more common than the soft shield fern, but in the south of England the soft shield fern is the more abundant of the two. The hart's-tongue is less common in parts of Scotland where the winter temperature is very low, and where there is no suitably alkaline substrate for it to grow on. The narrow buckler and the lady fern are found mainly in wetter places.

A rare species of *Dryopteris*, the hay-scented buckler fern (*Dryopteris aemula*), also grows in deciduous woodland. It is distinguished by the scent of hay it exudes when rubbed, and by the frond stalk which is dark brownish-purple at the base and lighter above. Found mainly in the south-east and south-west of England, and in the west of Wales, Scotland and Ireland, it grows only in broad-leaved deciduous woodland where the tree canopy is high enough to keep the level of humidity high.



Above: The lady fern (*Athyrium filix-femina*) takes its name from the delicate appearance of its fronds. Although it can be variable in form, the J-shaped sori on the underside of the leaves are a good identifying feature.

Right: In late spring, the tightly curled young fern fronds start to appear, like these of the male fern. The brown scales protect the young fronds during the winter, before they begin to unfurl.

FIGHTING FERRETS –RABBIT HUNTERS

Ferrets–polecat-like mammals long used for rabbit hunting–are generally regarded as untrustworthy animals that will bite ferociously at the slightest excuse. Properly managed and handled, however, they can prove to be quite docile.

Ferrets, members of the family Mustelidae, which includes the pine marten, stoat, weasel and polecat, are domesticated animals kept widely in Britain for sport and the control of vermin.

Two types Ferrets occur in two basic forms: the polecat-ferret and the albino. Albino ferrets are sometimes pure white, but are more usually a pale yellowish-cream colour. Like all true albinos, they have red eyes.

Polecat-ferrets, on the other hand, have pigmented coats, their fur usually being dark brown, black or, more rarely, a sandy red colour. These ferrets are so-called because they resemble wild polecats. There is, in fact, no doubt that all ferrets are descended from polecats, although it is not absolutely certain exactly which species is the ancestor.

The suggested ancestors are the marbled polecat (*Vormela peregusna*), the steppe polecat (*Mustela eversmanni*) and the European polecat (*Mustela putorius*). The marbled polecat is not a likely contender, for it is more like a skunk than a polecat in appearance. To date, no one has managed to cross the marbled polecat with a ferret. Similarly, the steppe polecat will not interbreed with domestic ferrets, and so by elimination the most likely ancestor is the European polecat. When you look at the two together this makes sense, for the dark form of the polecat-ferret has markings very similar to those of the polecat, including the 'bank robber's mask'. In addition, ferrets will breed with the European polecat, and the European polecat, when tamed, can be used with great success for ferreting.

Sinuous hunter The ferret is an active carnivore. When on the move it glides along sinuously, its body held rather low to the ground because of its relatively short legs. Like wild polecats, the ferret takes a very wide range of food, including rats, mice, voles, rabbits, eggs and birds. The word polecat is derived from the French 'poule chat' ('chicken-eating cat')–and ferrets do indeed have a penchant for chickens.

Many ferret owners feed their voracious charges on day-old chicks; the young ferrets do well on this diet, as long as it also includes

Above: An albino ferret–note the red eyes. In both the albino ferret and the polecat-ferret the males are called hobs and the females jills. A hob is substantially larger than a jill, weighing 1-1.3kg (2-3lb); the jill rarely exceeds 600g in weight.

Below: A polecat-ferret on the prowl. This animal closely resembles the European wild polecat. Small populations of these animals exist in the wild in Britain.

Right: A polecat-ferret and (below) the right way to handle a ferret. One of the first records of domesticated ferrets comes from the 1st century AD when the historian Strabo described how a plague of rabbits was kept in control by ferrets. The histories of rabbits and ferrets are interlinked: as rabbits were introduced across Europe, so too were ferrets. They were certainly established here by Richard II's time, when a licence was needed to hunt rabbits with them.

red meat from pigeons and rabbits. Powdered milk and pellet foods are useful substitutes.

Breeding The male ferret (hob) comes into breeding condition in January or February. It is easy to tell because it then develops a very strong smell, the stink glands producing a creamy musk. Hobs must be separated at this stage because they will fight each other ferociously when kept in confined conditions. The female (jill) comes on heat slightly later in the year and stays in breeding condition until mated. Jills do not fight together as much as the males, though it is advisable to separate them before introducing a hob.

Ferrets ovulate only after copulation. This is known as induced ovulation and is a mechanism that ensures that ova are released only after mating and therefore are not wasted. Mating is by no means graceful; the hob grabs the jill by the scruff of her neck and bites her sharply before carrying her off to some secluded corner. Copulation is noisy and may last for over half an hour.

Pregnant jills do best if provided with a nest of clean hay or straw. During pregnancy they always moult, losing much of their fur. They are ready to give birth after about six weeks, which is the same time as that required by the wild polecat. Hobs may eat the newborn young and are therefore generally separated from the jills after mating. The jill herself may even eat her young if she is stressed in some way.

The kits Young ferrets are called kits. At birth they are not much bigger than the top joint of a human thumb. They are pink, hairless, blind and totally helpless and weigh about 20g (about the weight of a 10p piece). Their fur begins to grow after a few days and it is then that the type of ferrets bred becomes clear. Albino ferrets produce albino offspring, but a polecat-ferret crossed with an albino produces a mixture with a darker fur. Polecat-ferrets also tend to produce offspring of mixed colours.

Ferrets are prolific breeders; there are seldom fewer than four young in a litter, and six is more usual. Twenty ferrets have been born in one litter–and raised–but this is rather exceptional.

At four weeks old the kits' eyes open. After five weeks the youngsters are able to eat solid food, such as minced fresh meat, and bread and milk. A week later the kits attack almost anything presented to them in the expectation that it is food. Their sharp teeth have appeared by this stage and can inflict serious wounds. Soon after this the kits are usually separated from their mother. Ferret owners wanting to use their young animals for sport then accustom the kits to being handled. To avoid the usual furious biting onslaught a wise owner feeds his young ferrets before attempting to pick them up; they are less aggressive after a meal.

The sport The sport of ferreting is as ancient as the ferret itself, having been practised for 2000 years or more. The main quarry is the rabbit, but some go for rats as well. Foxes are too formidable a prospect for most ferrets, but a few owners will try to match their ferrets against them. Many millions of people have practised ferreting; some have been notable, including Ghengis Khan and the Emperor Frederick II of Prussia.

Ferreting

The traditional ferreting season for rabbits is from September to March. A warren with plenty of rabbits is selected in advance, such an area being called a bury. Nets are set over every burrow exit in the bury, a purse net being the type most often used. It has draw strings that close round behind the rabbit when it bolts into the net, holding it firm. Two jill ferrets and one hob is a typical combination for a small bury. The jills do most of the work and are put down into the rabbit burrow first. It may take quite some time for the jills to move the rabbits from the maze of tunnels and galleries they know so well. A muffled thundering of feet announces that the rabbits are bolting for the surface; they soon rush headlong into the awaiting nets. When all the rabbits have bolted, the jills return to the surface where they are picked up. Sometimes, however, the jills kill a rabbit underground and then, after eating it, curl up and go to sleep. It is difficult to stop this so, to locate a feeding or sleeping jill, the hob is brought into action. It is put down the burrow, quickly locates the kill and drives the jill off. The jill then returns to the surface. The hob, which has had a piece of string tied to its collar, is then recovered by digging.

FERRET (*Mustela furo*)
There are two forms–the albino and the polecat-ferret.
Size Head and body 30-44cm (12-17in), tail 13-18cm (5-7in).
Colour Albino is white or creamy yellow, polecat-ferret is dark brown, black or sandy red (rare).
Breeding One litter of 4-6 or more kits a year.
Food Rats, mice, voles, rabbits, eggs, songbirds, invertebrates, chickens, pigeons.

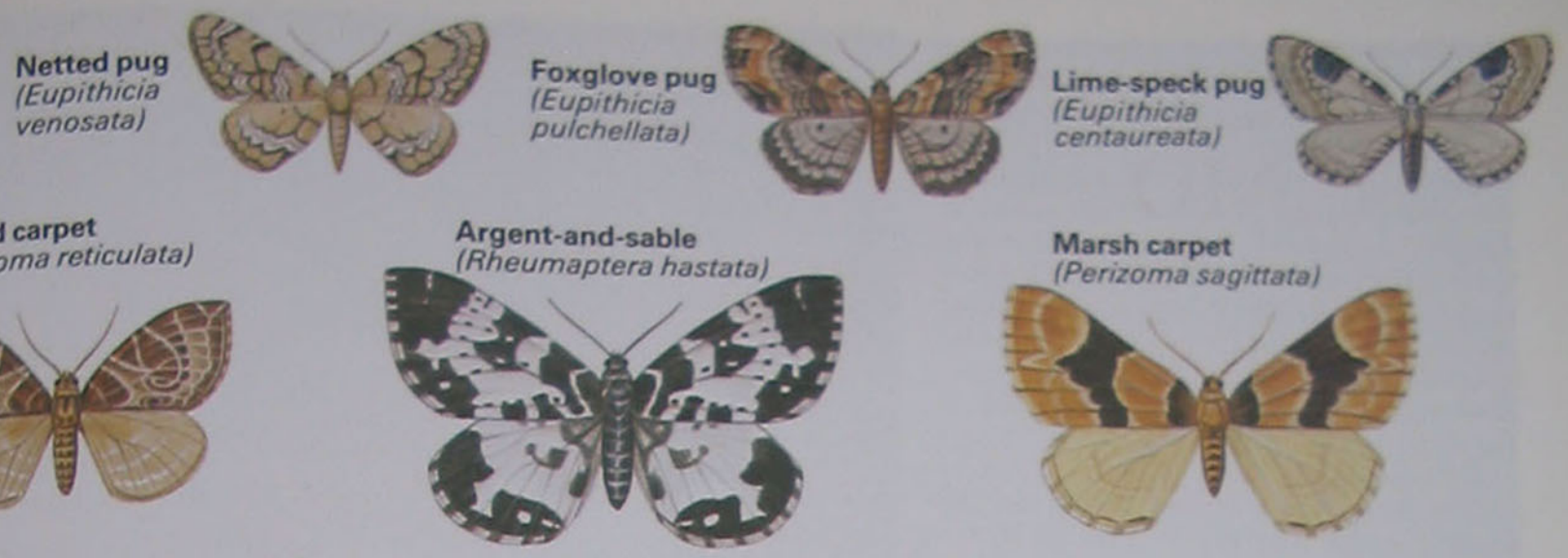
CARPET AND PUG MOTHS

Despite their names, carpet and pug moths have nothing to do with either carpets or dogs – they are named from their small size and attractively patterned wings.

Carpet and pug moths together make up the sub-family Larentiinae of the large moth family Geometridae. About 167 species are found in Britain, some 53 of which are species of pugs. Most are breeding residents and many are widespread, although a few are intermittent migrants from the Continent.

Colour and pattern Carpets and pugs are small moths, with wingspans varying from as little as 12mm (½in) to 4cm (1½in). Carpet moths are so-called because of the intricate, carpet-like patterns which they display on their forewings. The underwings are generally of a more uniform tint – at the most they are faintly barred. The patterns on the forewings may consist of a series of wavy or angular

Below: Several species among the carpets and pugs are predominantly green, an otherwise unusual colour among moths and butterflies. The green carpet (*Colostygia pectinataria*), shown here, is perfectly camouflaged against the lichen-covered tree trunk. Most carpet moths rest with their wings outspread, although some hold them upwards, like a butterfly. Pugs usually rest with both fore and hind wings spread flat and fully exposed.



lines of varying extent and different colours, superimposed on a pale background colour. There is frequently an additional, more or less solid, central band of colour angled towards the wing-tips.

Few of the species are vividly coloured, although some are yellow or reddish, or bear patches of blue or purple. An unusual feature of the Larentiinae is that the predominant colour in several species is green, although this is otherwise a rather rare colour in the Lepidoptera as a whole. Typical green species are the green carpet, autumn green carpet and the green and V-pugs.

Many species display considerable colour variation which is frequently, although not invariably, linked with their geographical distribution. An example is the attractive netted pug, which exists as four sub-species in the Scottish islands. The Scottish and Irish races of the yellow shell, another variable species, are darker than the typical delicately banded yellow form. The forewings of the variable common marbled carpet may be whitish, rusty yellow or even nearly black. Many other species of carpet moths are very similar to each other, and some were at one time considered to be merely races or varieties of one main species.

Pug moths are particularly difficult to identify, mainly because of their small size and variable patterns. In some cases, the only sure means of identification lies in the removal and microscopic examination of the male genital claspers.

Cryptic camouflage The wing patterns of most carpet and pug moths enable the insects to merge with their surroundings when at rest during the day. Such patterns often imitate the appearance of tree bark, as in the case of the small waved umber. This species has a broad lateral stripe on each wing which joins to form a single, continuous irregular streak, resembling a fissure in the bark. This pattern also helps to break up the moth's outline, further protecting it from predators.

Another camouflaged species is the yellow-ringed carpet which is found on northern moorlands. It has yellowish scales on its wings which blend with the lichen-covered stones on which it rests by day.

Larentiinid caterpillars are equally difficult to spot because of their small size, cryptic coloration and their habit of resembling twigs when resting. Some species have reduced pigmentation because they feed inside flowers or seed capsules, where they have little need of protection. The caterpillar of the cloaked pug, which feeds within spruce cones, is one such example.

Flying carpets Both carpet and pug moths fly in a rather weak, fluttering manner but despite this, a few species do manage to migrate to Britain from Europe.

Most of the moths are active only at night, when they are frequently attracted to artificial

Below: Carpet moths are named from the patterns on their wings, which are likened to a carpet design in their intricacy. The patterns generally consist of wavy lines of colour on a pale background, often with a central band of another colour, as seen here. The underwings are usually much duller and only faintly patterned. This common carpet moth (*Epirrhoe alternata*) is found in gardens and hedges and can be rather variable in coloration.

Right: The wingless female winter moth lays her eggs in bark crevices or in the angles of twigs on fruit or other trees, which she has to climb after emerging from her underground cocoon. The eggs overwinter, hatching in spring to produce caterpillars that are serious pests on the tree foliage on which they feed. A method of pest control is to prevent the female climbing the trunk to lay her eggs by painting a ring of gummy material round the tree bole.

light. However, a number of species – such as the variably patterned July highflyer and the treble-bar – fly during the day, usually in bright sunshine. One of the larger members of the family, the treble-bar can be recognised by the three irregular bands of lines across its ash-grey, reddish-tipped forewings. It can be found in calcareous regions, especially where its larval food plant, St John's wort, grows. An unusual and distinctive day-flyer is the little chimney-sweeper which is uniformly black except for a narrow streak of white on the tip of its forewings.

Although most carpets and pugs fly during the summer, there are some exceptions. The shoulder-stripe, for example, is seen in March and April, whereas the drab coloured mallow flies in the autumn. A few species, including the aptly named November and winter moths, emerge in the winter and may be on the wing from about October to February. Another variation in the life-cycle is seen in the tissue moth, which overwinters as an adult to emerge again the following spring.

From egg to adult The moths lay their eggs on a variety of trees, shrubs and other plants, both wild and cultivated, low-growing species such as bedstraws being favoured by many species.

Larentiinid caterpillars are of the 'looper' type. Their false legs (pseudopodia) are reduced to two pairs of hind claspers and they move in a very distinctive fashion. First the caterpillar thrusts its head forward and takes hold with the six true legs just behind it. It then draws its body up close behind so that both true legs and hind claspers are adjacent, with the body forming a loop. This mode of progress is common to all Geometridae ('Geometer' meaning 'earth measurer').

Pug moth caterpillars feed on the flowers, stamens and developing seeds of various plants, which involves them in some interesting life-styles. Foxglove pug caterpillars, for example, feed within the tubular flowers of foxgloves, sewing up the edges of the flower with silk to form a retreat. Some carpet caterpillars do likewise, one example being the rivulet, whose caterpillars consume the unripe seeds of campions and ragged robin. Cultivated plants, especially brassicas, are another source of food.

Several species overwinter as eggs or caterpillars, but most pupate in silken cocoons in the soil beneath the food plant. Many species breed quite early and produce two or more broods of adults during the year.

Diverse habitats Many of the commoner carpet moths can be seen in gardens and hedgerows, where disturbance may cause them to flutter a little way before coming to rest once more. The yellow spinach is a common garden dweller, deriving its name from its habit of resting on spinach plants, although its larval food plant is actually currant bushes. Common species with similar coloration are the handsome barred yellow,

Left: When resting on pine bark, the pine carpet (*Thera firmata*) is well camouflaged and matches its surroundings. Its reddish-brown forewings have the appearance of patches on the tree trunk where the pine bark has flaked away.

Below: The eye-catching barred yellow (*Cidaria fulvata*) is common in England and Wales in gardens and hedges, where it hides by day under leaves. If disturbed, it will flutter for a few metres before coming to rest again. Its caterpillars can be found feeding on both wild and garden roses.

Above: This garden carpet caterpillar (*Xanthorhoe fluctuata*) is moving with the characteristic looping motion across a sprout leaf, a common food source for Larentiinid caterpillars. Most species feed at night, resting by day in a looped position, or extended in twig-like fashion with only their hind claspers attached to the food plant.

Left: The striking broken-barred carpet (*Electrophaes corylata*) may be found in hedges in May and June.

and the paler barred straw, which can be recognised by the way in which it often rests, with its wings curiously up-folded.

The garden carpet, the silver-ground carpet and the common carpet are three very similar common species. They all have whitish wings with greyish-black or brownish wing-bars, and are therefore easily confused.

Chalky soils and scrubland are the homes of species such as the wood carpet, chalk carpet, pretty chalk carpet and Haworth's pug. The caterpillars of the last two species may be found feeding on traveller's joy.

Typical woodland species are the handsome blue-tinged beautiful carpet and the striking black and white argent-and-sable, which is normally found around birches. The spruce carpet, and cloaked and larch pugs are found in coniferous woodland.

The intricately marked scallop shell and the Manchester treble-bar are found on moorland, where their caterpillars feed on bilberry and other low-growing plants.

The seashore and saltmarsh habitats also support some species, such as the scarce pug, whose caterpillars eat only sea wormwood and related plants. Other species are typical of fens and water meadows and include the oblique carpet and the distinctive yellowish-brown and black marsh carpet, which is now increasingly rare as a result of drainage of its habitats and loss of its food, meadow rue.

THE BEAUTY OF THE BEACONS

The most southerly mountains in Britain are in the Brecon Beacons National Park in the counties of Powys, Dyfed, Gwent and Mid Glamorgan. Designated in 1957, the park provides high-level walking and pony-trekking over treeless moors and summits.

Below: The Black Mountain – covered with snow! The Beacons Park is noted for its swallowholes – funnel-like pits in the surface of the moorland, looking from the air like bomb craters. The largest is 46m (150ft) across and many metres deep. Confined to the areas of Carboniferous limestone, many of them are the result of collapses in the roofs of underground caverns as acid water off the peat moors has dissolved the limestone below.

The Brecon Beacons National Park, covering 1344sq km (519sq miles), is made up of four upland blocks. In the east are the Black Mountains; in the west, to confuse things, is the Black Mountain; and between the two are the Beacons themselves and Fforest Fawr. There are many heights of about 610m (2000ft), while on Pen y Fan the Beacons reach 889m (2916ft).

The uplands To explore the higher ground you could begin with the Black Mountains, perhaps making your way up from Hay-on-Wye or Llanthony to the heathery heights of Hay Bluff and its close neighbour, the Twmpa, with their magnificent northwards views across mid-Wales. Turning south, you can travel for miles from summit to undulating summit, taking in the highest in this section of the Park – Waun Fach – and passing on south again to Pen Cerrig-calch, which is noteworthy as a peak of Carboniferous limestone outcropping amid a world of old red sandstone.

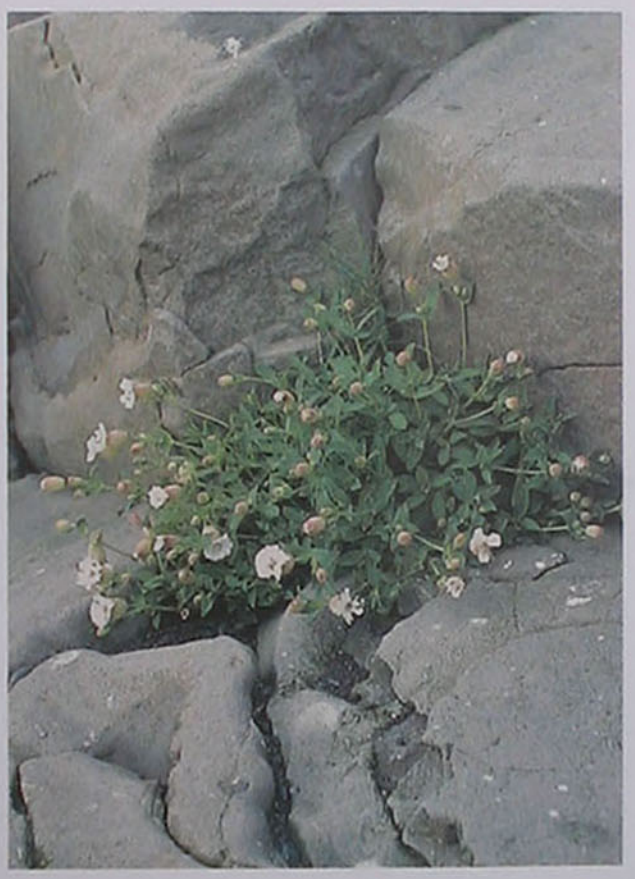
The craggy, triple-headed summits of the Beacons – Cribyn, Pen y Fan and Corn Dû – can be seen from across the wide valley of the Usk. Reaching nearly 900m (3000ft), these tough grits and conglomerates are the highest old red sandstone rocks in Britain.

West of the Beacons the land drops sharply to the Brecon-Merthyr road, but then rises just as quickly up the slopes of Fan Fawr, one of the summits of Fforest Fawr. Despite its name, Fforest Fawr (high forest) is not a forest but a treeless upland, the name 'forest' being a Middle Ages term for a royal hunting ground. West of Fan Fawr you can climb several other Fforest Fawr heights until you reach the loftiest of all – Brecknock Van. This is a sister summit to Carmarthen Van, which rises one mile to the west and is the highest point of the Park's westernmost section, the Black Mountain. From here there is an immense prospect all the way round from Cader Idris in the north to Exmoor in the south.

Streams and lakes Well blessed with rain, the uplands are the source of many sparkling streams, the longest and best-known of which

Right: A furry drinker moth – this and other moorland moth species, such as the northern eggar, the fox and the emperor, are fairly common on Brecon Beacons, but are most often seen as caterpillars. Among the Park's butterflies are the purple, white-letter and green hairstreaks, the comma and several fritillaries, including the marsh and silver-washed. There are also many dragonflies, especially at Llangorse Lake; and one rare insect – a very small damselfly of the uplands called the scarce ischnura. Grass snake, adder, slow worm and common lizard all live in the Park, and so do the common frog and common toad. Only two of the three British newts can be found there, however – the smooth, which is restricted to the lowlands, and the palmate, which reaches as far as the mountain regions.

Right, below: Sea campion, as an upland plant, grows no further south than Brecon.



is the Usk, which crosses or skirts most of the Park, for it rises in the west on the north side of the Black Mountain and then heads east past Brecon to divide the Beacons from the Black Mountains before flowing out of the Park just south of Abergavenny. With its slopes climbing high above green farmlands and patches of woodland, the fertile vale of the Usk is beautiful from end to end.

Three parallel deep valleys have been cut close to each other into the southern flanks of the Black Mountains by the streams called Grwyne Fechan, Grwyne Fawr and Honddu. The first two are tributary to the Usk, but the Honddu escapes east to the Monnow, then the Wye. From the Beacons and Fforest Fawr flow many streams that make their way south or south-west down the coal valleys of Glamorgan, the most remarkable being those at the head of the Vale of Neath. Here four streams – Hepste, Pyrddin, Mellte and Nedd – have sliced deep ravines in the Carboniferous limestone and fall over high waterfalls where they reach the more resistant millstone grit. A few of the limestone streams disappear below ground, for the rocks here are honeycombed by some of the longest and deepest caves in the British Isles.

Of the Park's few natural lakes, by far the largest is at Llangorse below the western slopes of the Black Mountains. This is a fertile lowland water with large reed beds. Unfortunately, it is grossly disturbed by a caravan site, power boats and water sports and has been polluted by sewage, detergents and agricultural fertilisers. There are now measures to rehabilitate the water but the problems of wildlife disturbance still persist.

On the Black Mountain are two fine neighbouring corrie lakes – Llyn y Fan Fach under the red sandstone crags of Carmarthen Van, and Llyn y Fan Fawr under Brecknock Van. Their rock-girt water is clear and pure but inevitably far less rich in life than that of Llangorse Lake which is 335m (1100ft) lower and set amid fertile soils.

The woodlands Although nearly all the original forest was cleared for farmland many centuries ago, there are still small tongues of broad-leaved woodland in most of the lowland valleys, mainly of oak with a scattering of birch, ash, alder and others. A few limestone slopes in the south are clothed with almost pure scrub-like ashwoods; and in the south-east there are relics of native beechwoods, the most westerly in Britain.

Here and there a quite alien type of woodland has been created by man, especially this

century–the extensive conifer plantations which cover large areas of the higher moorlands and also dominate some of the valleys, notably that of the Grwyne Fawr.

Wild flowers Most sandstones are limeless and have a mainly calcifuge (lime-hating) flora, but those of the Brecon Beacons Park are locally lime-rich and on the uplands they form soft, rotten crags with perennial water draining through them–perfect conditions for plants in great variety, including a number of mountain species which here are at or near their southern British limit. Purple saxifrage, mossy saxifrage and roseroot occur in profusion, and northern bedstraw, green spleenwort and the mountain form of lesser meadow rue can also be found.

Alongside the alpines is a luxuriance of lowland species which obviously enjoy the coolness, dampness and fertility of the often sunless lime-rich 'rocks–primrose, cowslip, burnet saxifrage, rock stonecrop, lady's mantle, wood anemone and a host of others.

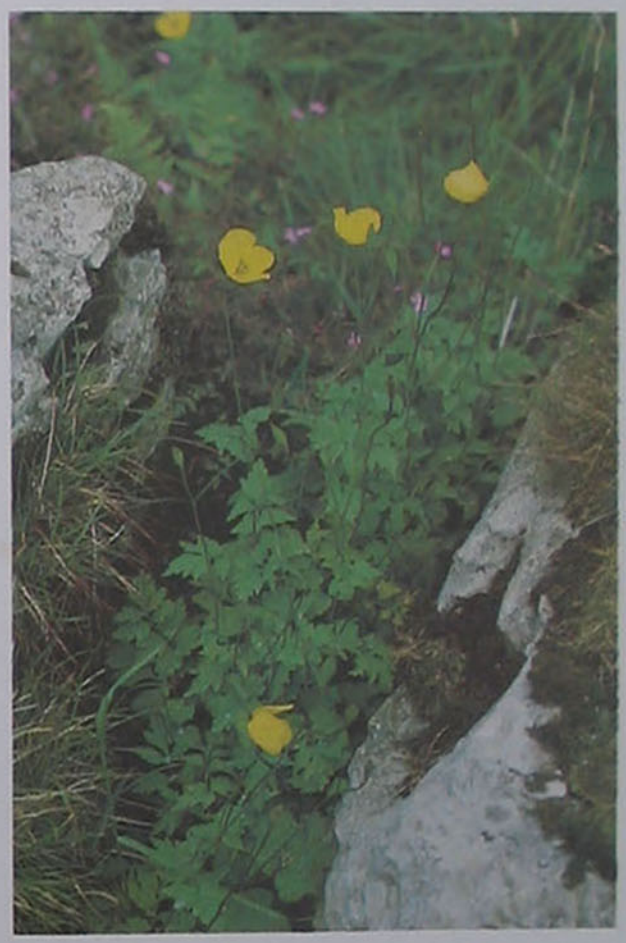
In the lowlands some of the best sites for wild flowers are the few pastures and meadows which have not yet been modernised by ploughing and re-seeding. Among the choicer species are meadow thistle, saw-wort, great burnet, dyer's greenweed, petty whin, whorled caraway, creeping willow, fen bedstraw, globe flower, wood bitter-vetch and various orchids and sedges.

In the oakwoods the most varied plant communities are those on the base-rich humus soils where there are plenty of ash trees among the oaks and alders in wetter places. Typical wild flowers are ramsons, wood sanicle, dog's-mercury, woodruff and yellow archangel, with toothwort and herb paris among the rarities. Most such woods flourish on well-watered ground in the valleys; but in the drier ashwoods of the limestone hillsides, such as those near Craig y Nos, the wild flowers are quite different. Among the characteristic species here are lily-of-the-valley, broad-leaved helleborine, shining crane's-bill, rockrose and green spleenwort. Besides the ash, the trees are mostly whitebeams and yews. The whitebeams are one of the most distinguished features of the flora of the Park. Some are very local or rare in Britain and two–*Sorbus minima* and *Sorbus leyana*–are found nowhere else in the world.

Water plants are at their best in Llangorse Lake where, despite the pollution that has reduced or exterminated some of the most sensitive rarities, there is still a fair range of resistant species, including three kinds of water-lily, common and lesser bulrush, greater spearwort, flowering rush, golden dock and narrow-leaved water-plantain.

The mammals of Brecon Besides the foxes, badgers, stoats and weasels found throughout the Park, two carnivores are worthy of special mention: the otter, which still thrives along the Usk, the Brecknock NT being a pioneer in the conservation of this now endangered

Above: On the heathery crags of Brecon the piping of ring ouzels is a persistent sound from April to July.



Opposite: A waterfall near Talybont in the Park–the scenery is typical of the area. Many of the Park's streams have brown trout, sea trout and salmon, the Usk in particular. The reservoirs are stocked mostly with brown and rainbow trout and locally with American brook trout. For coarse fish, the best locality is Llangorse Lake, where there are perch, carp and roach, along with large pike and eels.

Right: An appropriate member of the arctic-alpine plant community in Brecon–the Welsh poppy.

Brecon's geology and soils

In contrast with the Snowdonia National Park, where sedimentary rocks exist alongside huge quantities of igneous and metamorphic materials, the rocks of the Brecon Beacons are all sedimentary. The great bulk of them are reddish or purple sandstones, shales and conglomerates of the Devonian period and so are less ancient than those of Snowdonia. Many of them lie in horizontal strata which are clearly visible in the north-facing scarp faces. Older rocks are found only near Llandeilo and Llandovery, where there are Ordovician millstones and grits, and also Silurian shales and sandstones full of fossils.

All along the southern flanks of the Park are rocks of the Carboniferous period–limestone and millstone grit which are neighbours of the coal measures that lie immediately outside the Park in industrial South Wales. Throughout the Park there is evidence of the great Ice Age and its after-effects–scratched rocks, glaciated pavements, moraines, cirques, corrie lakes, ice-smoothed valleys and deposits of clay and gravel.

The canal

A canal to serve industry and agriculture was built alongside the Usk between Brecon and Gilwern near Abergavenny, and opened in 1812. Now restored after long neglect, it is used for pleasure boats and is a wholly delightful water-way that winds river-like through the vale for 33 miles, the only British canal almost entirely within a national park. For much of its course it is lined with trees and bushes and is a valuable haven for wildlife, harbouring perch, dace and roach among the fishes, and a variety of aquatic plants.

Opposite: On the acid rocks of Brecon grow parsley fern (shown here), viviparous fescue, cowberry and dwarf willow—but the willow is scarce and, at only 5cm (2in) high, hard to find.

mammal; and the polecat which, as in the rest of mid Wales, has survived in reasonable numbers.

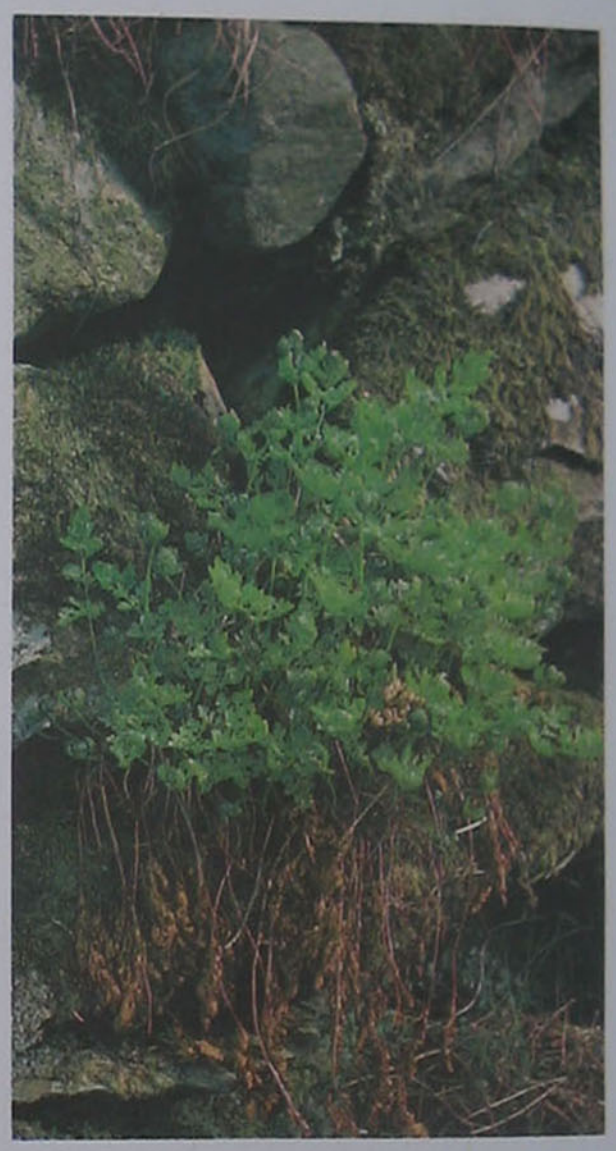
Small mammals—voles, mice and shrews—so crucial in the diet of many larger mammals and predatory birds, abound throughout the Park. The field vole is of special interest because of its occasional population explosions, as in 1956 when thousands of newly planted trees were ring-barked and killed by nibbling teeth. Bank voles and wood-mice are common, but the yellow-necked mouse is more local, and the harvest mouse has only been discovered in the Park in recent years.

Brecon birds Skylarks and meadow pipits are the only common breeding birds of high grassy places, but where there are screes or stone walls you will often see wheatears. The highest cliff ledges are nesting places for ravens, kestrels and (rarely) the peregrine falcon. On the heather moors there is a scattering of red grouse and here and there a merlin, while wet rushy hollows are the home of curlew, lapwing and snipe. Spring and autumn see a migratory trickle of a rare wader, the dotterel, but it is not seen every year.

In the broad-leaved woodland resident birds include nuthatch, treecreeper and all three woodpeckers. The buzzard—a bird of the mountains—is well-established, its mewing voice and graceful circling flight very noticeable in spring. Among abundant summer visitors are pied flycatcher, redstart, tree pipit, blackcap, garden warbler, wood warbler, willow warbler and chiffchaff.

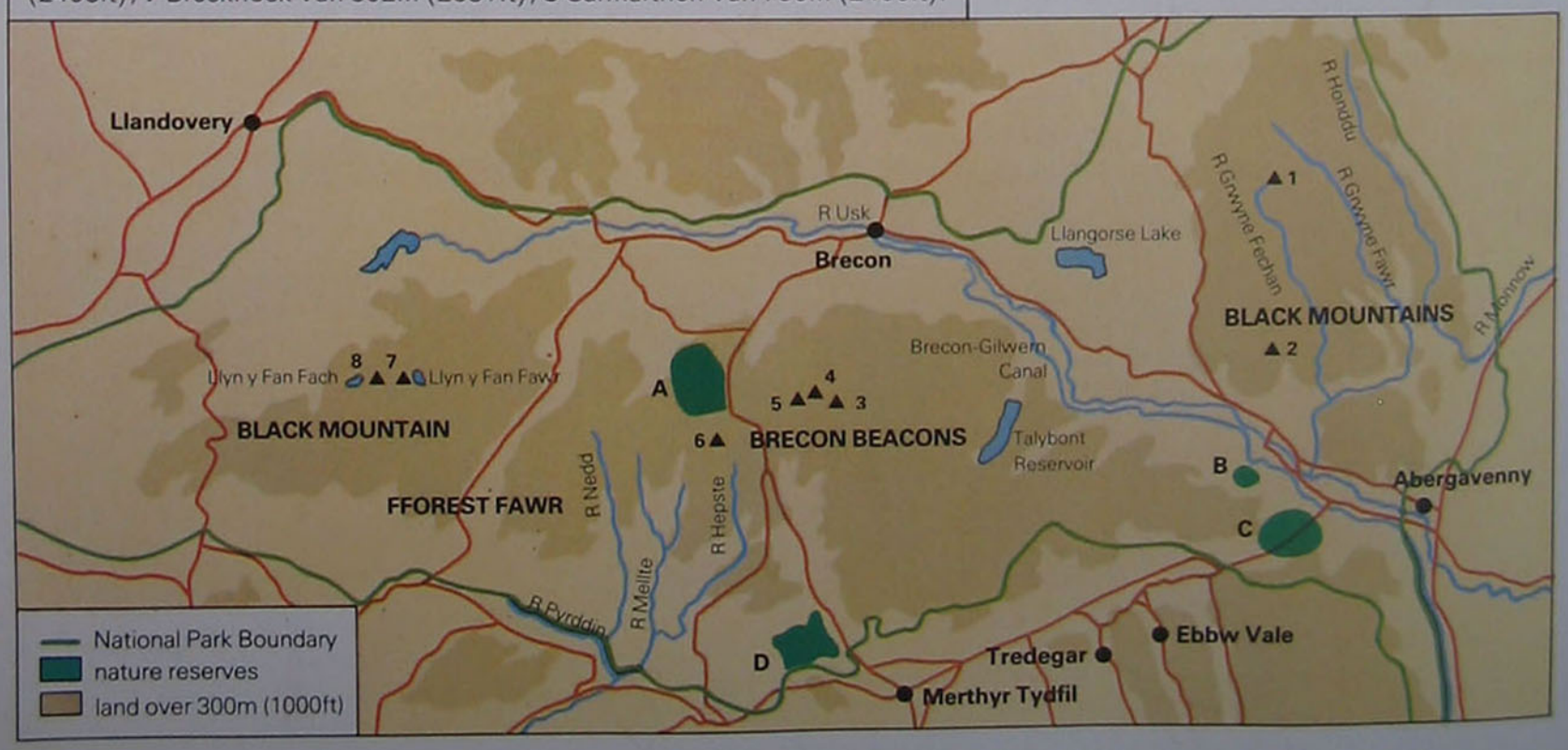
Where there are mature conifers you are likely to find goldcrest, coal tit and perhaps siskin, crossbill and sparrowhawk.

Characteristic water birds are dipper and grey wagtail on streams, and reed and sedge warblers and great crested grebe on Llangorse Lake. Migrants and waterfowl are specially watched for on Talybont Reservoir and Llangorse Lake.



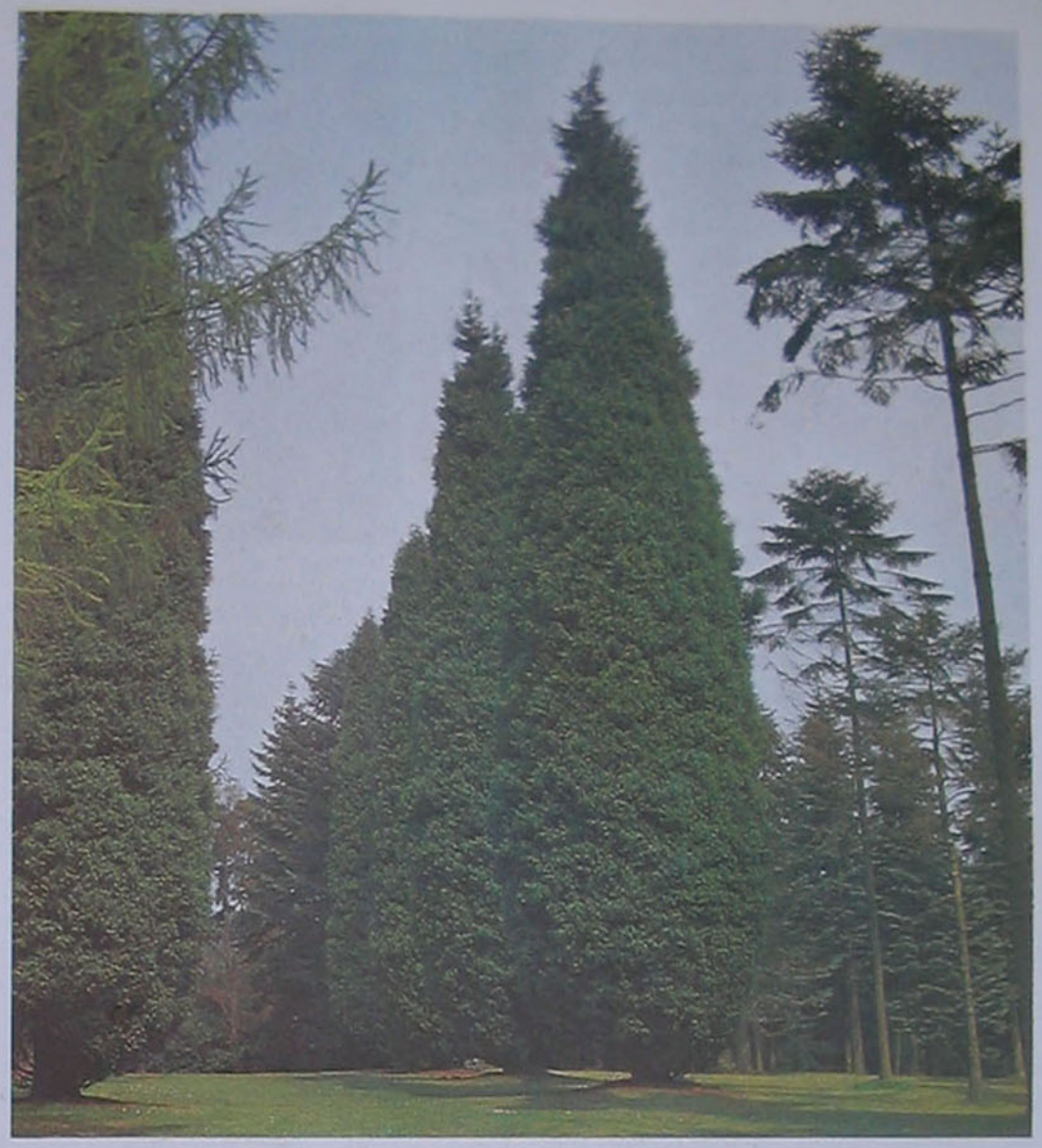
Reserves and mountain peaks

The Park has three National Nature Reserves: **A** Craig Cerrig-gleisiad, 6 miles south-west of Brecon; **B** Craig y Ciliau, 2 miles south-west of Crickhowell; **C** Cwm Clydach, 2 miles east of Brynmawr. There is also a Forest Reserve: **D** Penmoelallt, 3 miles north-west of Merthyr Tydfil. Full information about these reserves, and all other aspects of the Park, can be obtained at the excellent visitor centre of Mynydd Illtyd near Libanus, 4 miles south-west of Brecon. **Brecon's peaks**: **1** Waun Fach 811m (2660ft); **2** Pen Cerrig-calch 701m (2300ft); **3** Cribyn 795m (2608ft); **4** Pen y Fan 889m (2916ft); **5** Corn Dû 873m (2864ft); **6** Fan Fawr 734m (2408ft); **7** Brecknock Van 802m (2631ft); **8** Carmarthen Van 750m (2460ft).



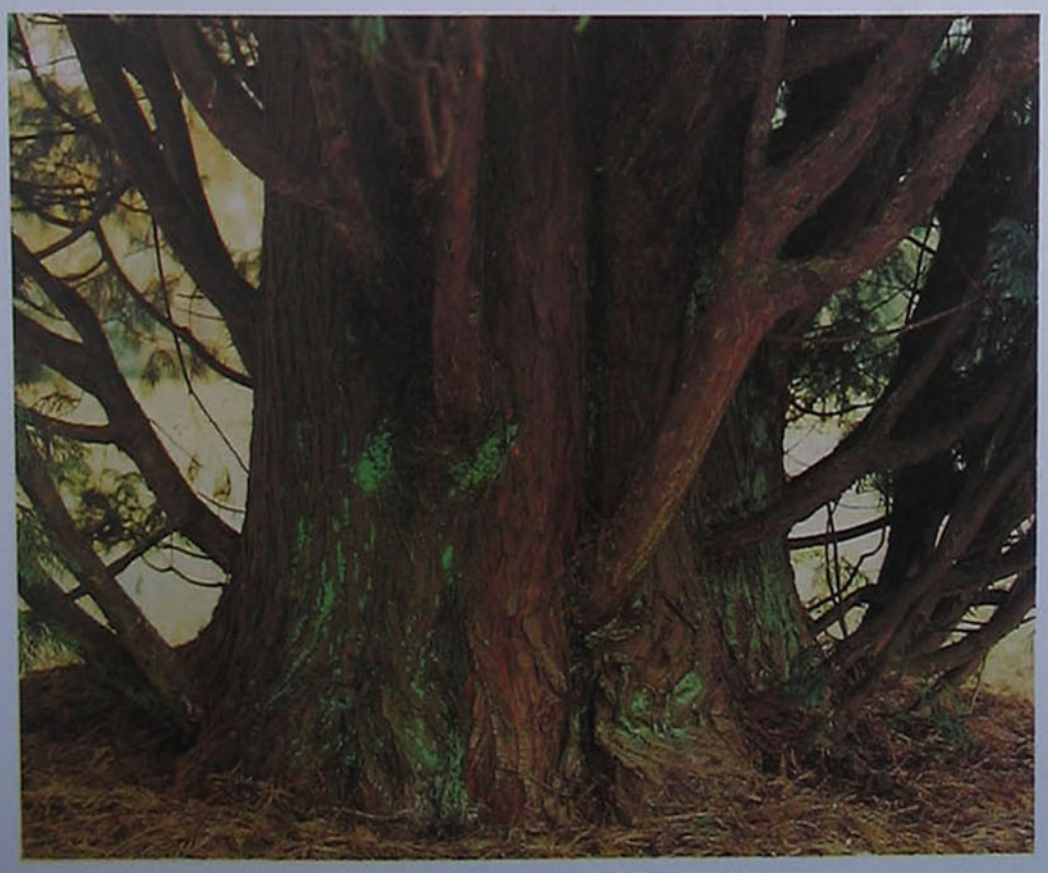
COLUMNAR CYPRESSES

Lawson and Leyland cypresses–two of the commonest conifers in urban and suburban areas–provide shelter for small birds and are often used for hedging or ornamental trees.



Above: Leyland cypresses–the crown is conical but the leading shoot tends to bend to one side.

Below: The branches of a Leyland cypress, like those of a Lawson cypress, arise from near ground level.



Cypresses belong to the family Cupressaceae, a group of evergreen conifers found in both the northern and the southern hemispheres. The family is characterised by its opposite leaves which are usually small, adpressed (hugging the twig) and scale-like. The cones usually have a number of seeds to each scale. The buds are minute and lack protective scales.

Lawson cypress This species is native to a small area in north-west California and south-west Oregon. It was introduced to Britain by the Oregon Association, a group of Scottish landowners who were interested in procuring seeds of many of the north-western American conifers for assessment for forestry potential. The original introduction was in 1854 to the Edinburgh nursery firm of Lawson and Son–hence the name.

Lawson cypress (*Chamaecyparis lawsoniana*) forms a tall, rather columnar tree that reaches a maximum of 40m (130ft) in cultivation here, although trees over half this height are exceptional. This compares with a maximum of 60m (200ft) in the best of its native stands.

Growth in height tends to be slow but steady. An average of 30cm (12in) a year is rarely exceeded, except over short periods. Growth in girth tends to be faster, and a short, stout, frequently forked bole is produced.

Mature trees lose the regular columnar habit and begin to develop a less formal crown. This has rather gaunt branches arching upwards and then down at the tips. Many trees, raised as cuttings from selected plants, do not naturally develop the usual open branching habit, instead remaining columnar and conical.

Bark and foliage The bark of young Lawson cypresses is a smooth purple-grey, often with a greenish tinge. It is slightly shiny. As the tree ages the bark 'fissures' into small scales on longitudinal ridges. In old trees the bark on these becomes fibrous and thick, reputedly reaching 50cm (20in) thick in old trees in their native environment.

The foliage consists of pairs of small scale-like leaves whose bases clothe the shoots. The shoots are arranged in flat sprays–a characteristic of *Chamaecyparis* species–and each pair of leaves is either in the same plane as, or at right angles to, the spray, alternate pairs having the same configuration. The sideways-facing pair are called laterals and those at right angles to the plane of the spray are called medians. The median leaves are broader and less prominent than the laterals.

The leaves are dark green above, although often yellowish or bluish green in vigorous new growth. On the underside the leaves are paler and there are white lines between the scales. The leaves breathe through the stomata in these lines. The white colour comes from secretions of glaucous wax which help to reduce water loss. On the small side shoots the white lines come together to form an X. Selected glaucous blue trees, and most seedlings from them, have a waxy covering over the foliage and over the lines between the scales on the upper surface.

Towards the end of the first year on strong shoots, but perhaps not until the third on weak ones, the scale leaves cease to function. On the strong shoots they turn brown and form the first layer of bark; on weak shoots the whole twig is lost.

Cones The male cones of Lawson cypress are carried on the end of the weakest shoots. They open in late winter or early spring, when they are red and purple. By April they are 4-5mm long and begin to shed their yellow pollen. After the pollen is shed the cone drops off.

Female cones are blue-green and composed of eight scales. They are carried on short shoots formed near the vigorous tip of the branch. At the time of pollination the cone scales are open and the ovules or egg cells individually visible. After they have been pollinated the scales expand in an attempt, never entirely successful, to close over the seeds, the wings of which can usually be seen projecting between the scales. Each female scale carries two to five seeds.

The mature cones are globular in outline but rather lumpy in detail. Each scale is shield-like in shape and sited on a centrally placed stalk. The scales are four- to five-sided, with a ridge running across them. The cones ripen to brown in the autumn.

The seeds are flattened and narrowly winged along both sides. They are ovate in outline, with conspicuous pockets of resin. The germinating seedlings have two cotyledons–a general characteristic of the cypress family. The first true leaves produced by the seedling are linear and awl-like. Scale leaves are produced only in the second year.

Above: The male cones of a Lawson cypress open in late winter or early spring. The foliage (below) consists of scale-like leaves whose bases clothe the shoots.

Leyland cypress Frequently seen as a hedge plant, Leyland cypress quickly forms a screen and, once established, grows 90cm (35in) a year over many years. However, left unclipped it forms a fine tall tree, usually attaining a height of about 30m (100ft). As a hedge plant it is adequate, although it does require frequent clipping.

The Leyland cypress (× *Cupressocyparis leylandii*) is a hybrid between the Nootka cypress (*Chamaecyparis nootkatensis*) and the Monterey cypress (*Cupressus macrocarpa*). Its crown is columnar and conical, and the leading shoot is inclined to one side.

The shoots are usually not set in the flat sprays characteristic of *Chamaecyparis* species, nor in the markedly three-dimensional sprays of *Cupressus* species. They occur in intermediate sprays in two or more planes. The scale leaves are dark green above and a paler, yellow green beneath.

Cones are infrequent on Leyland cypress. When female cones are produced they are 2-3cm (about 1in) across and bear about five seeds to each scale. The tree itself is sterile. Its two parents are genetically too dissimilar to allow it to produce viable seeds. It has all the characteristics of a hybrid between two distant species–and exhibits 'hetorisis' or hybrid vigour, a phenomenon in which hybrids are less susceptible to disease than their parents.

Lawson cypress

Right: Lawson cypress 'Golden King'. In cultivation this species displays great variability and over 250 different cultivars have been named.

Below: Young cones on a Lawson cypress 'Green Hedger'.

Left: The Leyland cypress (**1**) is a hybrid between the Nootka cypress (*Chamaecyparis nootkatensis*), a hardy attractive tree with a conical crown of hanging branches (**2**), and the Monterey cypress (*Cupressus macrocarpa*), a true cypress (**3**). Since the parent trees belong to different genera the Leyland cypress is called a bigeneric hybrid, its scientific name being × *Cupressocyparis leylandii*. It first appeared at Leighton Hall, Welshpool in 1888.

TOOTHED WHALES OF THE OCEANS

Toothed whales are mostly social animals, living together in various combinations of males, females and young, a few, such as the sperm and killer whale, being polygamous. They live mainly in deep waters, although some become stranded around our coast.

Below: Bottlenose whales, the largest and most sociable of the beaked whales, are fairly common around the British coast and are usually seen in schools of a dozen or so, and occasionally up to 50 animals.

Of the 80 species of whales and dolphins, the great majority belong to the sub-order Odontoceti, the toothed whales. Five of the six families of toothed whales occur occasionally in British waters. It is often difficult to tell whales apart, but all toothed whales have a single blow-hole, and all but the sperm whale, white whale and narwhal have a dorsal fin of distinctive shape and location.

In general the large toothed whales are known as whales, and the small ones as dolphins although, rather confusingly, three members of the dolphin family–pilot, killer and false killer whales–are usually called whales. Other species of toothed whale include the sperm and pygmy sperm whale, several beaked whales–bottlenose, Cuvier's, Sowerby's, True's and Gray's–and a number of dolphins and porpoises. The smaller dolphins and porpoises will be discussed in a later article.

Most toothed whales have conical teeth. Some species, such as most dolphins, have rows of continuous pointed teeth in both jaws; others, such as the beaked whales, have a single tusk-like tooth in the lower jaw and very often the females just have gums. In the male narwhal the left upper incisor tooth undergoes extraordinary modification, forming a single long spiralled tusk.

Feeding The sperm whale eats mainly squid and other cephalopods, often catching them at great depths. It is not unknown for squid

almost the size of the sperm whale itself to be eaten by males, although they mostly take squid of 30-100cm (1-3ft) long. Because squid are difficult to catch with man-made equipment the analysis of sperm whale stomachs has provided scientists with useful information about these elusive creatures. Furthermore, as some squid only occur in certain parts of the world, the stomach contents can give clues to the areas the whale has visited.

The capture of fast-moving prey requires different skills from those needed by the baleen whales, which simply sift plankton out of the oceans. Some people think this is why toothed whales tend to mature slowly and have relatively well-developed nervous systems.

Most toothed whales do not show great north-south movements, although local migrations do occur. However, the sperm whale (particularly a lone male) undergoes extensive migrations, often of several thousand kilometres, from the tropics to feeding areas in high latitudes.

Other toothed whales eat both fishes and

Deep-sea diving

The male sperm whale is the deepest diver of all the cetaceans, and this ability may well be associated with the enormous spermaceti organ contained in the whale's vast head. In a 30,000kg (30ton) whale this organ may contain 2,500kg (2½tons) of waxy spermaceti oil. This oil is liquid at 33°C (91°F), its temperature in the whale at the water surface, but it begins to solidify at 31°C (88°F), becoming denser, and therefore less buoyant, as it does so. Scientists think that careful regulation by the whale of the temperature, and thus the density, of the spermaceti oil through various means may enable the animal to control its buoyancy on very deep diving expeditions, and actually allow it to be neutrally buoyant at depth.
The names 'sperm whale' and 'spermaceti' were originally given to this species by people who believed it carried its semen in its head. In the past the oil has been used in the making of cosmetics, lubricating oils and cleaning materials.

Above: The vast sperm whale, the largest of the toothed whales. Its head is a third as heavy and large as its body. This species is found in all the oceans of the world, although only single males occur in Polar waters and the records of stranded sperm whales on British coasts have all been of male animals. Sperm whales take in oxygen for about ten minutes and then dive as deep as 1000m (3300ft). and stay underwater for up to an hour.

Below: The pilot whale is all black except for a conspicuous white throat patch. It becomes stranded, often with other pilot whales, comparatively frequently around the British coast. Stranded schools may exceed 200 animals.

Above: The killer whale. The reputation of this species as an animal dangerous to man is almost certainly false, or at least greatly exaggerated. It might occasionally attack man, mistaking him for a sea mammal. But certainly a killer whale in captivity, well-fed with fishes, co-exists amicably with dolphins, upon which it preys in the wild, and allows its trainer to play with it at close quarters.

cephalopods. The pilot whale, for example, feeds mainly on cephalopods but also takes shoaling fishes such as herring. During the last few centuries pilot whale populations in the Faroes have fluctuated according to herring catches. The white whale also feeds on fishes such as herring, salmon and cod, as well as squid.

The killer whale has an even more varied diet. It takes a variety of fishes and squid, and commonly eats seabirds. It is the only species known to be predatory on other marine mammals, including seals. Packs of killer whales even feed on large whales twice their size – usually old or sick individuals. The dorsal fin is usually attacked first and then the tongue, a favourite morsel.

Distribution Sperm and killer whales are distributed throughout the world's oceans, but some species are much more localised, including the distinctive narwhal and the white whale (or beluga), both of which occur in Arctic waters and only rarely come into British waters.

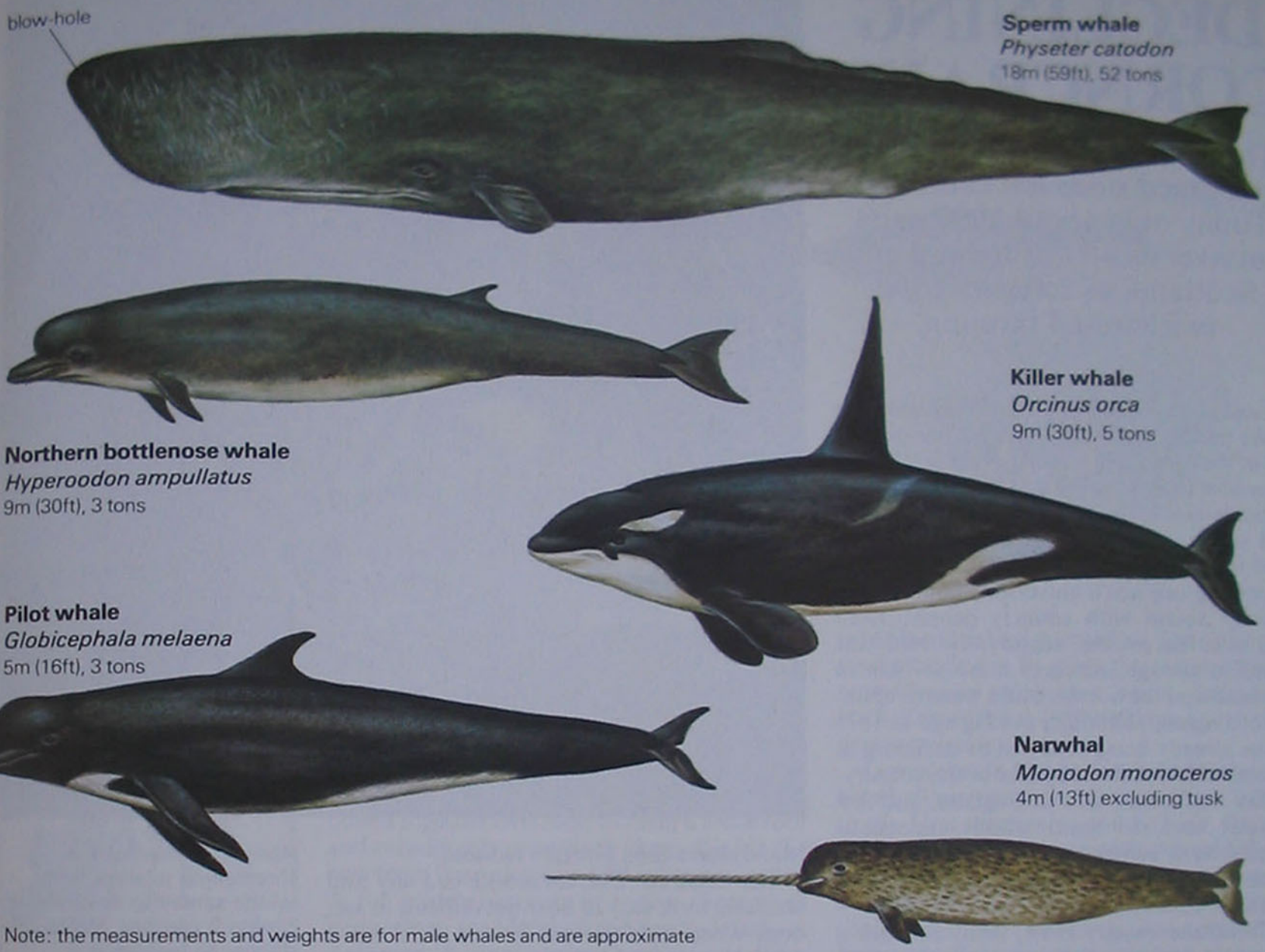
Sperm whales are deep-sea animals and so they tend to be seen just off the Continental shelf around the British coast, particularly south-west Ireland and north-west Scotland where the shelf edge comes closest to the mainland. Occasionally they may come right into the coastal waters: a herd of females and young was seen one recent autumn in the Pentland Firth, and a male was sighted in Scapa Flow, Orkney, at Christmas 1981.

The pilot whale is relatively common, particularly in autumn when it follows mackerel shoals to inshore waters of south-west England and Shetland. It spends most of the remainder of the year ranging over the north-east Atlantic and the northern North Sea in herds of up to 100 animals, and is one of the most frequently stranded.

Killer whales occur in much smaller herds, usually fewer than 15 individuals, particularly along the west coast of Britain in coastal waters, where they feed on grey seals and seabirds, as well as fish. Some sites are traditionally visited, especially in mid to late summer: the coast of Lewis and Harris, the Outer Hebrides and the Farne Islands are good places to spot them.

Elusive whales Although quite a lot is known about sperm, killer and pilot whales,

Toothed whales



Note: the measurements and weights are for male whales and are approximate

little is known about the beaked whales. This is almost certainly because they tend to be pelagic, living in deep waters, and are rarely observed. Some, such as True's and Cuvier's whale are known almost exclusively from stranded specimens. More is known of the northern bottlenose whale. It occurs in concentrations in particular areas of the north-eastern Atlantic, right up into the Arctic near Spitsbergen and Bear Island.

The false killer whale occasionally comes inshore and becomes stranded in large numbers. The reason for these mass strandings is not clear. Despite its name, this species is not related to the killer whale and, indeed, it looks quite different; it is much smaller, with a rounded snout and underslung lower jaw, and it looks rather like a bulbous shark.

Social structure During the relatively long period of maturation, the young learn how to find and capture prey from their elders. The sperm whale has perhaps the most complicated social system of the toothed whales. Groups may comprise any of the following: all female or bachelor male herds, females with calves, or one male with a group of females and a few sub-adult males. If a male with a harem becomes old or injured he may be replaced by a younger male from a bachelor herd and he then goes off alone, covering great distances into higher latitudes. It is probable that there is fairly intensive fighting between males in competition for a harem.

The male sperm whale is unusual in having a large spermaceti organ in its head. One reason for this may be that it is used for sparring between males, rather in the way the antlers of red deer are used. This is known as sexual selection: large males may attract more females to their harem and consequently have more offspring. Another reason may be the whale's deep diving habits.

The head of a group of sperm whales, whether a harem master or a female with a herd of calves, tends to be an older member and the most experienced. The practice among whalers of taking the largest animal has been very disruptive to the social organisation of schools of whales.

Killer whales exist in similar social groups. Killer whale herds have been studied closely in various parts of Canada where scientists have been able to recognise individuals and follow their movements. The groups appear fairly stable and faithful to the same areas.

Above: Some of the toothed whales that may visit British waters. The left tusk-like tooth of the male narwhal may grow to 2.5m (8ft) while the right tooth remains embedded in the upper jaw. In the female neither of the teeth is visible.

Opposite: A beached sperm whale. Mass strandings of toothed whales are not uncommon, although they are little understood. One theory is that they cannot echo-locate properly in shallow water. Another is that roundworm parasites in the ear may prevent effective echo-location. When people have tried to drag the whales out to sea, they have often merely turned round and become stranded again.

DECLINING CORNCRAKE

The corncrake population has declined since last century. Today only about 2000 pairs survive, mostly in Ireland and Scotland, as refugees from mechanised farming.

On still, warm evenings during May and June in the middle of the last century, the rasping call of the corncrake was one of the celebrated sounds of the countryside. The 'corn' part of its name is something of a misnomer for the bird is less an inhabitant of cornfields than it is of hay meadows and rough pastures; but its craking call was a universally familiar and popular sound with country people. Even well into the present century the bird was common enough, nowhere more so than in Scotland and the northern and western counties of England, although as long ago as 1875 it was already being reported as declining in several widely scattered parts of the country. Today it is a rare bird in England, and few popular and (to man) wholly innocuous species have suffered such a demise as the unobtrusive corncrake has during the course of about a hundred years.

Corncrake enquiry How, then, did such a dramatic change in fortunes occur? In 1938-39 an enquiry was initiated into the distribution and status of the corncrake, and the causes for its decrease. By this time it had disappeared completely from many counties, particularly in the east and south of England in the predominantly arable areas, and had declined seriously in many other areas such as Cheshire, Yorkshire and much of Wales. The enquiry had little difficulty in pinpointing the causes, as it could be shown conclusively that there was a very close link between the reduction of corncrake numbers and the spread of mechanised mowing of the hay harvest. In those areas where the cutting of the hay coincided with the birds' breeding season, a high toll of eggs and chicks was taken annually. Formerly with hand scything the nests or broods were easily seen and invariably spared, but now the corncrakes were literally being cut out of existence.

In those parts of the country where mechanisation was slower to arrive or less universal, the decrease was less marked; even so, with the continued introduction of improved grass strains the hay harvest was by then being taken progressively earlier in the summer, and so even the great corncrake strongholds of western Ireland and the Scottish islands have been pitifully reduced.

The 'landrail' The corncrake is a shy and skulking bird, easy to hear but difficult to see, even when it is present in one field for a whole season. In this respect it is similar to most of the rail family (its alternative name used to be the landrail). It spends little time in the open; when it does it is most often seen flying apparently weakly with trailing legs. It is a slim brown bird, three or four inches smaller than a moorhen, with bright chestnut wing patches; the brown colour of its upper parts is prettily marked with black streaks running down the centres of many of the feathers. Its legs are dull greyish-green, and its short bill and stumpy tail again bring to mind a comparison with the moorhen.

African travels The corncrake is a summer visitor to Europe from the eastern half of Africa, so its weak-looking flight belies a high degree of flying competence. From September to November the birds cross the Mediterranean and the Sahara to the grasslands of east Africa, starting back from March onwards, to arrive in western Europe in late April to May.

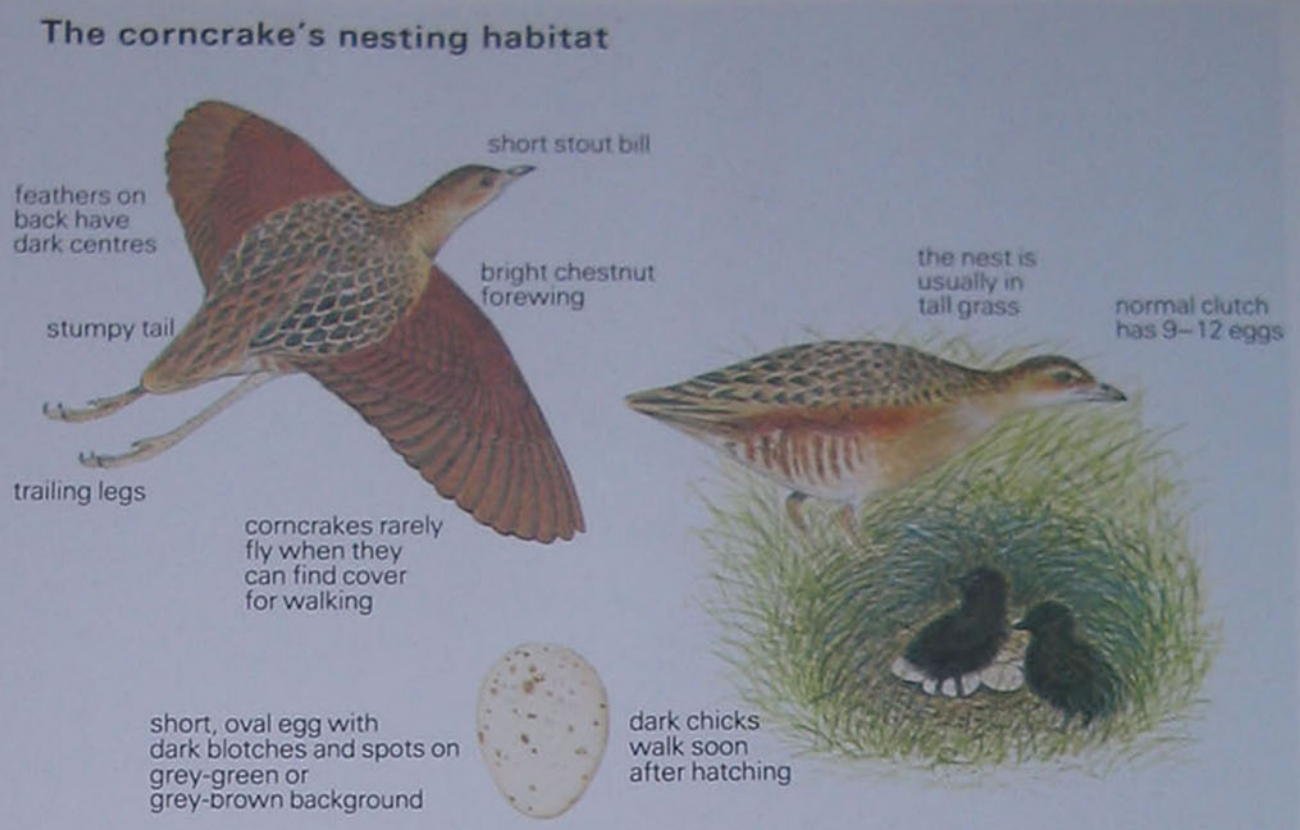
Both in its winter quarters and in Europe the corncrake is an omnivorous feeder, living on insects such as ground beetles, grasshoppers and craneflies, but also taking large numbers of snails, spiders, earthworms and other terrestrial invertebrates along with a few larger items (frogs and even young birds)

Above: A corncrake in threatening posture, with wings spread to show the chestnut patches. Males display to females in a somewhat similar manner, but with the neck stretched out and the stumpy tail raised and fanned.

Right: Without doubt the best-known feature of the corncrake is its repetitive 'crek, crek, crek, crek' call, issued mainly in the evening and onwards from dusk to dawn, but to a lesser degree by daytime, too. Exciting though it is to hear a corncrake's call nowadays, it can be rather monotonous. It is well known by naturalists that by mimicking this sound—either vocally or by drawing a thin piece of wood across the teeth of a comb—you can lure the bird to come close, gaining a chance of a good view. When calling, the bird stretches itself vertically to a remarkable height for such an apparently compact species. After a while, the female is attracted into the territory of the calling male.

Corncrake (*Crex crex*): summer visitor to rough pastures and grasslands; absent from south-east England. 27cm (10½in).

Right: The normal nesting habitat of the corncrake is in tall grass–hay meadows and rough pastures –in Ireland, western and northern Scotland. When the nest is made the grass or other vegetation can be woven into a roof or screen to hide the eggs or brood from predators. Foraging corncrakes, too, are well concealed in grassland, for they rarely fly, preferring to walk under cover all the time. Flying corncrakes are seen in September, migrating across England towards the Continent, and in April or May on the return journey.



and green shoots. The corncrake feeds in the long grasses of its chosen meadows, stretching up from time to time to peer warily through the tops of the grasses.

Nest in the grass The nest is a shallow cup of grass stems and leaves, concealed in growing vegetation, often with adjacent stems pulled together overhead to form a loose roof and presumably to assist in camouflaging the nest from passing crows and other predators. A full clutch has nine to twelve short, oval eggs, which are blotched and spotted dark on a grey-green or grey-brown background. Both sexes share in the 17 or 18 days' incubation, and the dark young chicks are fed for the first few days by the female before becoming fully capable of feeding themselves. Soon after the young birds can fly strongly, the southward movement is under way again, taking the birds 5000-6500km (3000-4000 miles) to their winter quarters.

Corncrakes in Europe and Asia Corncrakes breed all across central Europe from Ireland to the Ural mountains and beyond, far into Asia. It is in the intensively cultivated European part of its range where the corncrake numbers have been so badly reduced. Here all countries from Sweden to Italy and from Ireland to Bulgaria have reported severe reductions. Unlike most other crakes and rails, the corncrake tends to avoid wet, marshy areas and chooses thick stands of grasses, nettles and other rough vegetation. In the Hebrides and northern Scottish islands, however, the birds often select damper sites along stream sides and wetter fields in areas characterised by rushes, yellow irises and meadowsweet. This habitat is quite untypical.

Dwindling species So the corncrake survives today, clinging to a reducing toe-hold in Britain. Its future must seem a sorry one, for there is little prospect of anything but continuing decline on the evidence of more recent investigations in 1968-72 and in 1978-79. At present the breeding population is probably about 2000 pairs, strongly concentrated in western Ireland and north and west Scotland. Apart from the unequal battle against modern farming methods, the species, always flying at low altitude, has suffered badly from collisions with overhead wires, and in the face of heavy losses in the breeding season this factor may also have contributed to its decline. The unfavourable weather which has characterised many of the springs and early summers of this century may well have been another cause.

Above: The roach is a typical freshwater fish showing many of the external features necessary for life in water. The streamlined body is clothed with a protective but flexible covering of scales. The lateral line system—which detects vibrations—is visible along the side of the body as a thin white line. Propulsion is provided by the tail, powered by banks of muscle running the length of the body. The other fins—dorsal, anal, pelvic and pectoral—act as balancing organs, keeping the fish stable in the water.

FISH: BUILT FOR AN AQUATIC LIFE

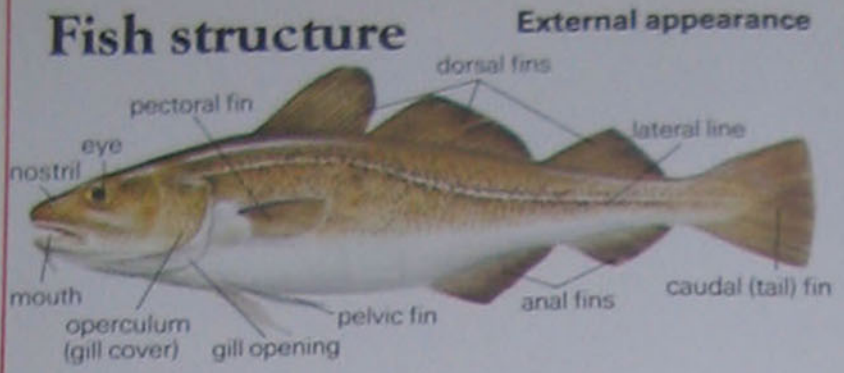
With about 22,000 species, fishes are the most abundant group of vertebrate animals in the world. It comes as no surprise, therefore, to discover that there are many variations in their anatomy. However, nearly all fishes share certain basic characteristics which enable them to spend their lives in water.

Fishes differ from other vertebrates (with the exception of the whale species) in being totally dependent on water for the whole of their lives. They have retained gills with which to breathe and fins for locomotion. Bony fishes—all those excluding sharks, rays and jawless fishes—share with other vertebrates a backbone consisting of a series of linked bones (vertebrae), a brain encased within a bony skull, and a highly developed sensory system.

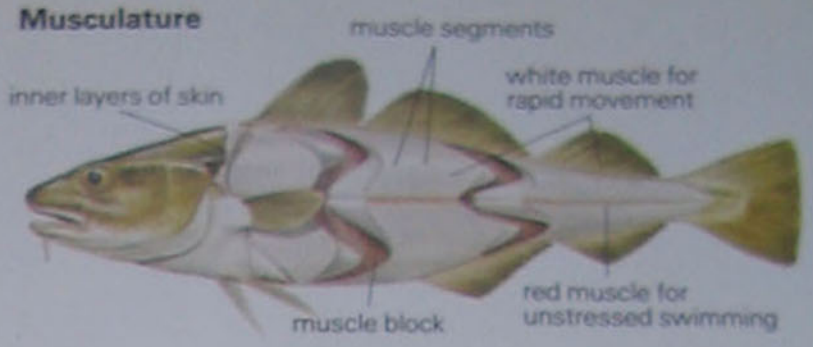
Scaly bodies Externally, one of the distinguishing features of most fishes is their scales. In many species these form a tough covering over the body. There are several kinds of scales found in fishes, but most British species of bony fishes have bony-ridge scales. Typically these are thin and translucent, with their outer surface covered with concentric ridges alternating with depressions.

The scales of bony fishes are classified into two kinds. Cycloid scales are smooth edged and generally more or less circular. Ctenoid scales tend to be more rectangular and always have fine teeth on the free edge (the edge not embedded in the fish's skin). Fishes with cycloid scales include the herring, pike, salmon and roach; those with ctenoid scales include the perch and bass. But the type of scales is not an important factor in classification, for the dab has cycloid scales on its white side and ctenoid on its coloured side, and among the

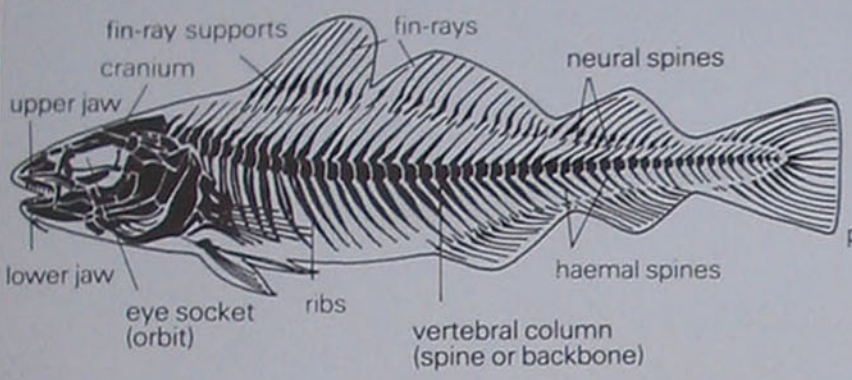
Fish structure



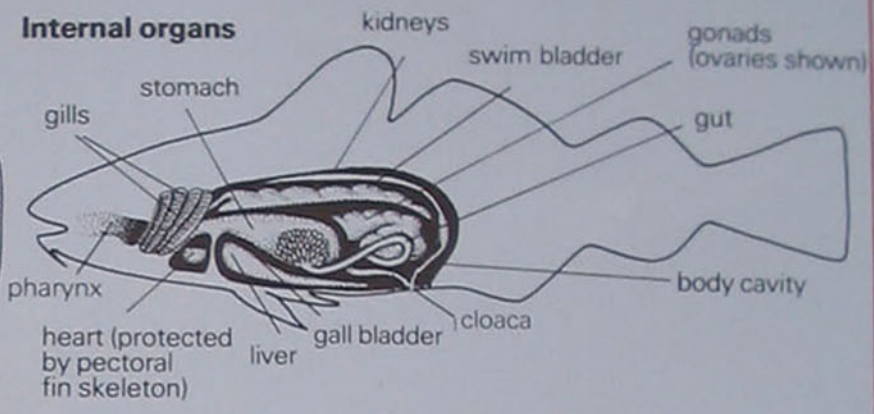
Above: Externally, the most obvious features of a fish are its scales (present on all but a few species) and its fins, which provide balance and manoeuvrability.



Above: Lying just beneath the scales are an outer and inner layer of skin and then the fish's muscle system – overlapping blocks of red and white muscles.



Above: All bony fishes have a backbone that extends down to the tail with spines branching off to support the muscle system.



Above: Apart from a few specialised organs necessary for survival under water, a fish's internal organs are similar to those of a land vertebrate.

eels, the freshwater eel has cycloid scales deeply embedded in its skin, while the conger eel has no scales at all.

The scales are just one element of the outer covering of a fish, however, for on its outer surface of the skin there is an ultra-thin layer of epidermis and beneath that there are other layers.

Muscle-bound If the skin of a fish is removed, its body is revealed as comprising a mass of muscle blocks arranged in zig-zag pattern down each side. These provide the swimming power for the fish, and they are huge in comparison with the propulsive muscles of most other vertebrates. Each muscle block is attached by ligaments to a vertebra, or to the spines which arise from the vertebra, but it lies at an angle to the mid-line of the fish so that each block overlaps, or is overlaid, by its neighbours. The millions of muscle fibres in each block on one side of the fish contract in sequence, and each muscle block on that side also acts in sequence with the other muscle blocks, so that a gentle wave of contraction moves down the body swinging the tail to that side. The muscles on the other side of the body then contract so that the tail sweeps to the other side. This side-to-side tail sweeping produces the typical swimming action of a fish.

Fishes have two types of muscle: red and white. In normal (ie, unstressed) swimming it is mainly the red muscle that provides most of

Left: Hunter's eye. This close-up of a pike's eye shows clearly the bulging pupil, caused by the lens being positioned close to the front of the eye to give maximum field of vision. The eyes of many fish are situated on the sides of the head, but predatory fish such as the pike have eyes that are set towards the front of the head. This enables them to judge distances better – essential when dashing after fast-moving prey.

Left: The jaws of a pike are armed with rows of sharp, backward-pointing teeth. Once seized, prey has little chance of escaping. Many less predatory fish do not possess teeth in their jaws. Instead, they sometimes have pharyngeal teeth. These are special bones located in the pharynx, and used to crush and chew food.

Above: The body of an eel appears to be scaleless, although it does in fact have scales; they are just deeply embedded in its skin. The scales of a fish such as the bass (left) are much more obvious. The bass has ctenoid scales which bear fine teeth on their free surface. The cycloid scales of the salmon (below) are smooth edged, and more circular in outline than ctenoid scales.

the power. However, when a fish is alarmed or has to move rapidly, the major mass of white muscle is employed.

The two types of muscle differ in composition and physiology, and their relative proportions provide a clue to the life style of a fish–much red muscle in the constantly moving mackerel, but very little in the pike, a fish which remains still much of the time.

Air supply Some of the colour of the red muscle is due to the abundance of blood vessels, for this muscle requires a steady supply of oxygen since it is continually in action. The absorption of oxygen from the water is remarkably efficient, even though water holds relatively little oxygen by comparison with the atmosphere. Oxygen is removed from the water by the gills as the water passes over them, having been gulped in at the mouth and expelled through the gill openings.

The blood-red colour of the gills is due to the presence of numerous arteries and veins and literally millions of capillary blood vessels. Supported by the curved, cartilaginous gill arch, the gills lie in a double row on the outside of the arch. Each row consists of closely packed gill filaments–visible with the naked eye–while each filament is further divided into microscopically small plate-like structures called lamellae. It is at the surface of these lamellae that carbon dioxide diffuses from the blood to the water and oxygen diffuses in. Oxygenated blood then flows to the

head and body through the dorsal aorta, urged on by the pumping action of the two-chambered heart.

Body organs The heart is situated low down in front of the body cavity, usually protected by the massive skeleton of the pectoral fins. Within the body cavity lies the gut, often a relatively simple tube (as in the carp family, members of which have no true stomach), although sometimes it is extremely long, as in the grey mullets.

The liver usually takes the form of a pale, lobed organ at the front of the cavity, but its size and colour vary greatly with the species of fish, and with the condition of individual fishes; the gall bladder is closely associated with the liver.

The kidneys are hard to distinguish and lie close to the spine in the roof of the body cavity. For several months of the year mature fish have large sex organs in the body cavity, either female ovaries with granular developing eggs (the hard roe of the fishmonger), or the testes of male fishes (known as soft roes).

Also lying in the upper part of the body is the swim bladder or gas bladder, generally a silvery tube and sometimes, as in the carp family, divided into two lobes. Among vertebrate animals the swim bladder is unique to fishes and has played a large part in their success. It is primarily a hydrostatic organ, its volume being regulated to enable the fish to remain almost weightless in water of varying salinity, temperature, and depth, without suffering the effects of changed pressure.

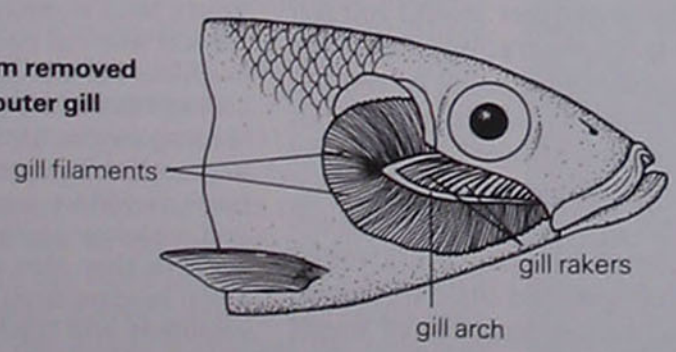
The swim bladder may also act as an acoustic organ. For example, the haddock, using muscles attached to the sides of the swim bladder, can make it resonate with a sound characteristic to the species. In other fishes, such as the carp, it is connected to the inner ear by means of a bone and acts as an underwater sound receiver, enabling the fish to hear keenly. Some fishes, but none of the species found in Britain, can use the swim bladder as an accessory organ to gulp air at the surface of the water–a capacity that presages the evolution of lungs in the higher vertebrates.

Above: The cod has three dorsal fins, the first of which is just breaking the surface in this photograph. It, too, has a prominent lateral line system. When breathing, water is expelled at the gill opening, or slit, seen here as a pale-coloured crescent just behind the operculum.

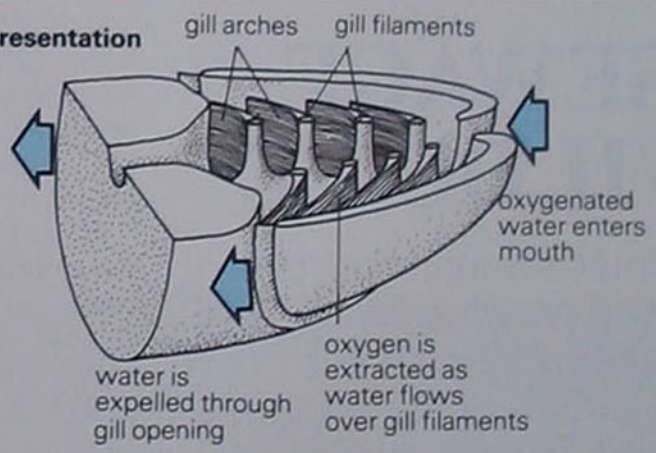
How a fish breathes

Below: Just beneath the gill cover (the operculum) the gill arches can be seen, supporting the gill filaments and rakers.

operculum removed to show outer gill



diagrammatic representation of part of head



Above: Water flows through a fish's mouth, across its gills, then out through the gill openings.

Fishes breathe by means of their gills, which are capable of extracting the tiny amounts of oxygen dissolved in water. On the right the operculum of a herring has been raised to show the blood-rich gills lying beneath. The gills are arranged as a series of filaments, supported by the gill arch running through the centre. Each filament is composed of microscopically small plate-like structures called lamellae; these increase the surface area of the gill and so improve its efficiency. Oxygen from the water diffuses through the walls of the lamellae into the bloodstream, while waste carbon dioxide diffuses from the fish into the water by the same route.

SEWAGE WILDLIFE

In winter sewage treatment works offer waders, waterfowl and many small perching birds a rich variety of invertebrate prey and seeds from grasses, sorrels and other plants.

Sewage disposal has created many interesting habitats for birds and other wildlife. In the early years of the century treatment of sewage was achieved simply by irrigating fields or impounding the sewage effluent in shallow lagoons. These were the so-called sewage farms, where the land was regularly ploughed and crops were grown in rotation with the inundations of sewage.

Migrant waders Birdwatchers quickly realised that these artificial wetlands provided a network of habitats across Britain for migrating birds in the spring and autumn. In particular it was migrant waders for which the sewage farms became justifiably famous. These birds were attracted by the rich invertebrate fauna of the sewage-enriched mud under the shallow water. Many of the farms were situated in river valleys which were probably used as major migration routes by the waders – thus the farms were ideally placed to attract large numbers of birds.

It is unlikely that any other inland habitat has attracted such a concentration of autumn waders as those recorded on some of the old sewage farms. The most numerous species were dunlin and ringed plover, with flocks often exceeding a hundred birds. Lapwing, common sandpiper, green sandpiper, greenshank, redshank, ruff, snipe, black-tailed godwit, curlew sandpiper and little stint were all regular visitors, with a long list of much

Above: A modern sewage works – the percolating filters carry a complex food-chain of life.

Below: Regular additions of organic matter to sewage works land encourage soil insects and – of course – earthworms. Consequently sewage farms are profitable feeding places for such migrating insectivorous birds as yellow wagtails and meadow pipits; in summer they also attract aerial feeders such as swifts, swallows and house martins.

scarcer species as well.

Three species in particular are worthy of special mention. Curlew sandpipers seemed to favour sewage farms more than other habitats – indeed, there are reports of larger flocks feeding on the farms than on the coast. Both the ruff and the green sandpiper, too, have started to overwinter regularly in Britain only during the last four or so decades and it is likely that this habit first started on the old sewage farms.

The sewage farms of the pre-war and immediate post-war years were exceptional sites for breeding wetland birds. Great concentrations of ducks, including mallard, shoveler, garganey and teal, bred at farms in the flood plains of such rivers as the Trent.

Above: Black-winged stilts in flight – in 1945 a sewage farm at Nottingham became famous as the only recorded nesting site in Britain of this rare species. More common waders on the old type of sewage farms included snipe, lapwing and redshank. Black-headed gulls and shelduck also appeared in some areas.

Below: Umbellifers in full bloom on the sewage works at Tring – the seeds from these plants feed a host of birds in winter.

Winter food In winter hundreds of ducks and waders used the lagoons and fields, both for feeding and roosting. Sewage farms were valuable for waterfowl because, in all but the coldest weather, large areas of wet land remained unfrozen. Farms operating a grass meadow cycle attracted spectacular influxes of birds on to any freshly flooded fields. Huge numbers of worms were drowned in these fields and this temporary food source was exploited by such birds as black-headed gull, lapwing, snipe, fieldfare and redwing.

Solid matter removed from the sewage was allowed to dry in earth-banked sludge lagoons. When dry these lagoons were ploughed and cultivated. Large quantities of seeds were present in the sludge and often the resultant weed growth – a mixture of such plants as tomatoes, mugworts and persicaria – was allowed to run to seed. This created a concentration of autumn food for hundreds, even thousands, of finches and sparrows.

Changes in sewage disposal Sewage farms required large tracts of land and they were gradually seen as an inefficient means of treating the ever-increasing loads of sewage emanating from our urban areas. The old farm system is now probably extinct in Britain; the trend has been towards more compact works in which wetland habitats contribute a far less significant part. Inevitably this means that fewer birds now visit sewage works; this applies particularly to wildfowl and waders.

Many modern works achieve oxidation of the sewage effluent through the use of percolating filters. These are usually circular structures with rotating booms from which the effluent is distributed over clinker or a similar substrate. The filters carry a complex food chain with a range of micro-organisms, fungi and algae supporting a wealth of mites, insects and worms which, in turn, are preyed on by other insects and spiders. The microbial film of the filters plays a crucial role in oxidising much of the organic content of the effluent.

A few modern works employ a final stage in effluent purification known as 'tertiary treatment'. Usually this involves irrigating land over a broad area and, in the process, creating an artificial marsh. The vegetation on these irrigation plots is dominated by various grasses, sorrels, nettles, umbellifers and, sometimes, reeds.

Birds of modern sewage works While the wildlife of sewage treatment works is not as spectacular as that of the obsolete sewage farms, it is nevertheless fascinating. The primary sedimentation tanks in which the solids are initially separated from the effluent are feeding places for wagtails and starlings throughout the year and, in winter, for gulls. The sludge drying beds also attract many insectivorous birds.

It is, however, the percolating filters that

attract especially large numbers of birds to many modern sewage works. The abundance of invertebrates on the filters provides a constant and reliable food source for wagtails, pipits and starlings. The range of birds recorded on filters is very large and even includes such unlikely species as chiffchaff, which winter at some Cornish works. Two of the main food items on the filters are earthworms and the larvae of owl-midges. Birds use the filters at all times of the year but the largest numbers occur in winter. Particularly in severe weather the filters can become crowded with feeding birds. At such times the filters offer starlings and wagtails one of the few unfrozen feeding sites for miles around.

Surface irrigation plots are the only extensive wetland habitats on modern works. These marshes are especially valuable today when damp grasslands, fens and bogs are rapidly disappearing from our countryside. The rank vegetation of these areas provides nest sites for large numbers of sedge warbler and reed bunting, while whitethroat, grasshopper warbler and reed warbler also occur. Where the growth is not too thick, snipe will sometimes nest and, especially when shallow lagoons are present, ducks, moorhen, coot and, less commonly, water rail are found. In winter snipe, teal, mallard, pied wagtail, meadow pipit and starling frequent these areas. Effluent lagoons are important wintering sites for wildfowl and waders, and can also attract migrating waders if the water levels are sufficiently low in spring and autumn.

Sewage boundary areas There are often other interesting wildlife habitats within the boundaries of sewage works. The margins may be marked by hedgerows or scrub which can support breeding birds not occurring elsewhere on the works–for example, turtle dove, woodpigeon, willow warbler, goldfinch, greenfinch and linnet. The finches may find plentiful food in the form of seeds on sewage works so it is not surprising that they often nest in larger numbers near sewage works than on surrounding land.

Banks and scrub frequently conceal fox earths and even badger setts. Another feature of many works are quite large areas of waste land with rank grasses, thistles and sometimes encroaching scrub. These are feeding grounds for finches and migrant birds such as the whinchat. Small mammals abound on the less disturbed parts of sewage works and consequently kestrels commonly hunt over them, catching voles and mice. Patches of short mown grass–typically found around percolating filters and buildings–also contribute to the richness of sewage works as bird habitats. Large flocks of pied wagtail, yellow wagtail and starling feed on these grasslands, often using them in conjunction with the filters or primary sedimentation tanks.

Above: Some of the most dramatic effects of sewage disposal on the distribution of birds are to be seen at coastal effluent outfalls. Enormous numbers of wintering gulls and ducks congregate at discharges of either domestic sewage or waste from breweries, granaries, food factories and so on. The birds are attracted both by the edible particles present in the effluent and also by the abundance of invertebrates which gather at sewage-enriched areas. Among the wildfowl typically found at outfalls are mute swans, scaup, pochard, eider and goldeneye. Gulls, noticeable because of their raucous cries, are always present.

Left: Little seems to have been recorded about the wildlife on sewage farms other than birds. However, the drier fields and embankments carry large populations of small mammals such as field voles, common rats (shown here) and bank voles. These small mammals attract birds of prey. Four species of owls –barn, little, tawny and short-eared–have been reported regularly, while kestrels seem to be the characteristic raptorial bird frequenting sewage works.

Autumn visitors to the sewage works

Kestrel
hovers on the wind looking out for prey such as field voles

Little owl
feeds on rodents, insects and worms, hunting at dawn or dusk

Black-headed gull
an occasional visitor

Lapwing
visits grassy areas from surrounding farmland

Fieldfares
feed on berries in the hedgerow during winter

Starlings
gather in large flocks to feed on the insects that live on the percolating filter

Greenfinch
feeds on weed seeds in winter

Ruff

Field vole
lives in areas of long uncultivated grass

Pied wagtails
gather in small flocks to feed on insects

wading birds are attracted to marshy areas to feed

Snipe

Green sandpiper

Reed bunting
visits tall vegetation by marshy areas for food

weeds

circular percolating filter

surface irrigation plot

THE GRACEFUL LILY FAMILY

The name 'lily' is often used to describe species with large and exotic flowers, although few of these are actually members of the lily family. True lilies are generally smaller and more delicate (but nonetheless attractive) species.

Opposite: As its name suggests, the spring squill (*Scilla verna*) is an early-flowering species. The delicate flowers appear from April to May.

Below: The star of Bethlehem (*Ornithogalum umbellatum*) takes its name from its supposed likeness to the Nativity star, and also from its abundance in the Holy Land. The white flowers appear from April to June.

The Liliaceae, the family of plants to which the lilies belong, encompasses world-wide over 2500 species, in a bewildering variety of forms and colours. The British members are a mixture of native species and plants introduced from abroad which have established themselves here, and they range from onions and leeks to tulips and bluebells, as well as the lilies themselves.

Native white lilies By far the most widespread, and indeed the only common native British lily, is the lily of the valley. This delightful species is a common garden plant, but in the wild it is a woodland denizen more or less restricted to the eastern half of the country. An extensive creeping rhizome

When is a lily not a lily?
Many species belonging to other families of plants have been given the name lily, often in praise of the shape or colour of their flowers. The water lily (right) is one of the most obvious examples, while several others belong to the daffodil family, which is closely related to the lilies. White flowers are often known as lilies, hence the snowdrop is sometimes called the drooping lily and the related summer snowflake is known as the Loddon lily. Our only wild daffodil, although not at all lily-like in appearance, is known as the Easter or Lent lily because of its flowering time.

system enables it to form large colonies on the woodland floor. The broad, oval leaves grow up in pairs directly from the rhizome and in spring a slender flower spike emerges from between the two leaves. The spike is unilateral–that is, the white, bell-shaped flowers hang on one side only–and the flowers give out a sweet, delicate perfume.

The May lily and Snowdon lily are also native to Britain, but both are now very rare. The May lily grows in a few sites in eastern England, although it sometimes appears elsewhere as a garden escape. Its slender rhizome sends up a stem with several leaves, but those at the base have usually withered by the time the flowers open, leaving only two oval leaves towards the top of the stem. The flower spikes consist of up to 15 flowers, each one being only about 4mm across.

The delicate Snowdon lily is even more restricted in its distribution than the May lily. It is now confined to rock ledges in Snowdonia, although it is widespread in the mountains of central Europe, Asia and North America. The Snowdon lily does not grow from a rhizome; instead, small bulbs produce slender, grass-like leaves and a stem bearing one or two star-shaped flowers, with the veins of the white petals picked out in purple.

Introduced species The Martagon or Turk's cap lily is rather more readily recognised as a lily than the species mentioned so far. That is, it has a tall, upright stem bearing whorls of leaves and at the top, a spike of large, colourful, nodding flowers with the petals curved up and back, and the long stamens thrust downwards. The flowers are flesh-pink or dull purple with darker spots and can be up to 4cm (1½in) across. The resemblance of the curved petals to the shape of a turban is responsible for the name Turk's cap.

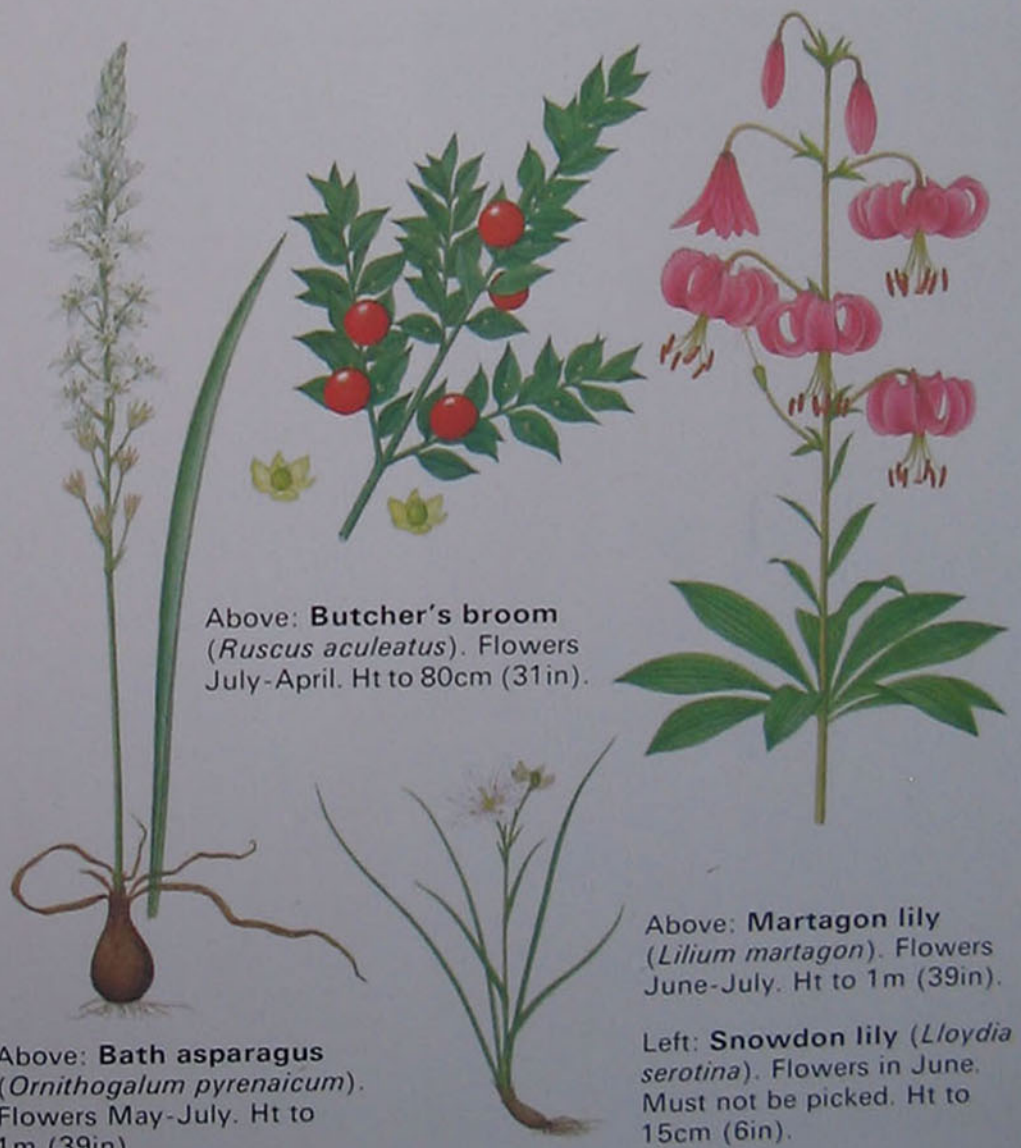
In some parts of the country at least, the Turk's cap lily is thought to be an introduced species, having escaped from gardens and established itself in the wild, especially in woods in southern England.

Another interesting introduction is the day lily. One species, *Hemerocallis fulva*, is a garden plant which, despite being sterile, has somehow still managed to escape–presumably as pieces of rhizome–and is now naturalised in some places. This vigorous species forms large clumps of long strap-shaped leaves and tall stout stems which support a cluster of orange flowers. Each flower is a flaring trumpet about 10cm (4in) long.

Blue and white lilies Other members of the lily family include the grape hyacinth, the squills, Solomon's seal and the species known as star of Bethlehem.

The grape hyacinth is easily recognised by its almost cone-shaped head of bright blue, drooping flowers supported by a single short stem. It grows in dry pastures in the east of England, especially in the Breckland and East Anglia. Although formerly widely cul-

Below: A few examples of the range of species and forms to be found within the lily family. The very rare Snowdon lily is protected under special legislation, and if you are lucky enough to find one, it must not be picked.



Above: **Butcher's broom** (*Ruscus aculeatus*). Flowers July-April. Ht to 80cm (31in).

Above: **Martagon lily** (*Lilium martagon*). Flowers June-July. Ht to 1m (39in).

Left: **Snowdon lily** (*Lloydia serotina*). Flowers in June. Must not be picked. Ht to 15cm (6in).

Above: **Bath asparagus** (*Ornithogalum pyrenaicum*). Flowers May-July. Ht to 1m (39in).

tivated, the plants now grown in our gardens are more likely to be larger-flowered species from Europe and Asia.

The star of Bethlehem grows in grassy areas in England and parts of Scotland and Wales; it has also been introduced into Ireland. The grass-like leaves have a white stripe running down the centre of the blade and each of the flower's six white petals has a green stripe running down the outer face.

The flowers are very sensitive to light and close up at noon, or even earlier in cloudy weather. This characteristic gave the plant a reputation for telling the time and it became a favourite 'clock plant' in old-fashioned gardens.

The spring squill, looking rather like a blue-flowered star of Bethlehem, also grows in grassy districts, usually in coastal areas. It is quite rare, appearing mainly in the west of Britain, but also in the north of Scotland and eastern Ireland.

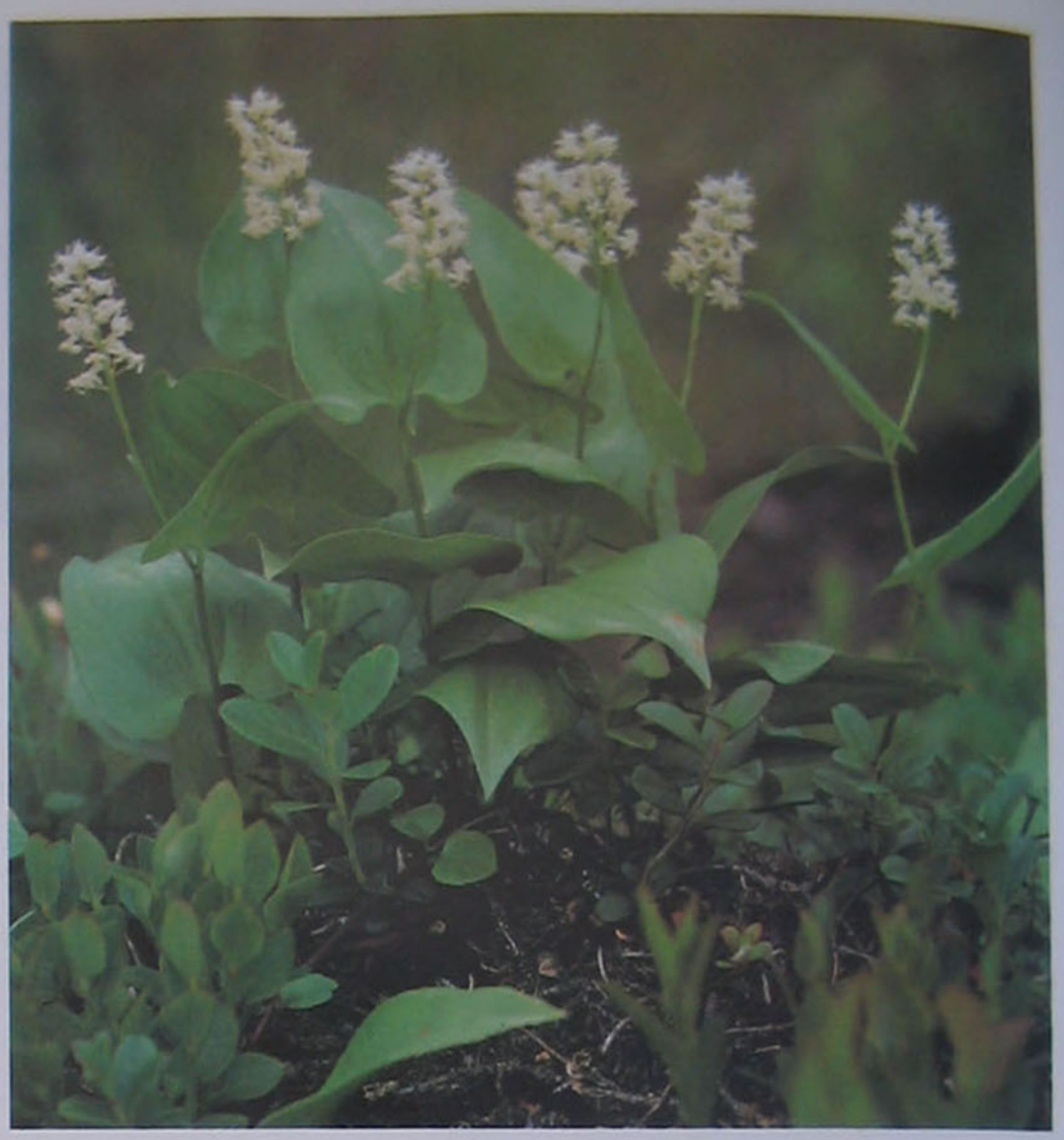
Edible lilies Asparagus is also a member of the lily family. One species, known as Bath asparagus, is not a real asparagus, but its young inflorescences were once sold as 'Bath asparagus' in the market of that town. It closely resembles a star of Bethlehem, but with smaller and more numerous flowers, and is also known as the spiked star of Bethlehem.

At first sight, true asparagus does not resemble other lilies, but the small, white, bell-shaped flowers and round red fruits that follow are very like those of lily of the valley and Solomon's seal. Garden asparagus is a tall, slender, upright plant and soft to the touch while wild asparagus has prostrate stems and is rigid and stiff.

The 'ferny' foliage of the real asparagus is quite familiar, but in fact its 'leaves' are not true leaves at all. They are modified side shoots called cladodes which remain green and take over the food-producing role of the leaves. The true leaves of asparagus are reduced to tiny whitish scales on the shoots.

Spiky species Even less like a conventional lily in appearance is the unusual butcher's broom. It, too, has cladodes but these are broad and flattened and resemble real leaves even more than those of asparagus. However, they reveal their true nature when the tiny green flowers appear. These grow in the centre of each cladode, whereas on real leaves they would grow in the angle between the leaf and the stem.

The flowers of the female plants are followed by large red berries, each situated (apparently impossibly) in the middle of a 'leaf'. The berries last from October to May and dried branches of butcher's broom, complete with berries, are used as colourful decoration in houses at Christmas and during the winter. The whole plant has a stiff, spiky appearance and is said to have been used by butchers for sweeping their meat-cutting blocks; hence its name.



Above: There are up to 15 tiny white flowers in each flower spike of the rare May lily (*Maianthemum bifolium*). It blooms in only a handful of woodland sites in eastern England from May to July and has a pleasant fragrance.

Left: Another member of the lily family, the meadow saffron (*Colchicum autumnale*) is often known as the autumn crocus because of its resemblance to a crocus (which is, in fact, unrelated and belongs to the Iris family). Unlike most plants, the meadow saffron begins its year in the autumn when the corm produces a single pale pink flower. At this stage, it has no leaves or stems and the base of the flower is below ground. Here the fruit develops, protected from the winter weather. In spring, the stem elongates, pushing the ripe fruit above the soil so that it appears along with the young leaves.

PARTRIDGES: GREY AND RED-LEGGED

Among our gamebirds are two species of partridge, both fairly common but both at present in a state of decline. One – the grey partridge – is a native bird, while the red-legged or French partridge was introduced successfully from the Continent.

Above: A red-legged partridge broods its chicks.

Red-legged partridge (*Alectoris rufa*); resident, introduced to England in 1790; length 34cm (13½in).

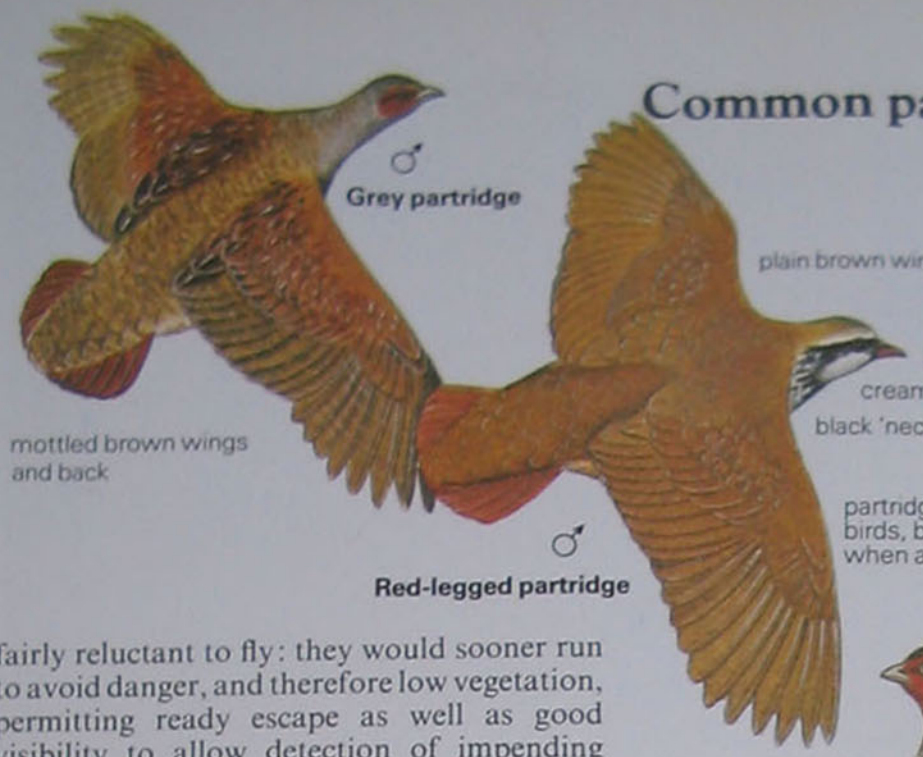
Grey partridge (*Perdix perdix*); resident native gamebird; 30cm (12in).

Considerations of sport and game have led to a variety of influences on our countryside – and the partridge population is a case in point. Game enthusiasts were not satisfied with the one species of partridge, the grey partridge, that is native to Britain and Ireland. Another species, the red-legged or French partridge, whose natural home is in south-western Europe, was successfully introduced into Britain (but not Ireland) in 1790, and its numbers have been maintained by the breeding of birds in captivity and also by subsequent introductions. A further two species, the chukar partridge, from south-eastern Europe and Asia, and the rock partridge of southern Europe, have been introduced in much smaller numbers, and the former has even hybridised with the red-legged partridge in some areas. To all intents and purposes, however, the two species a country visitor is likely to encounter are the grey and the red-legged.

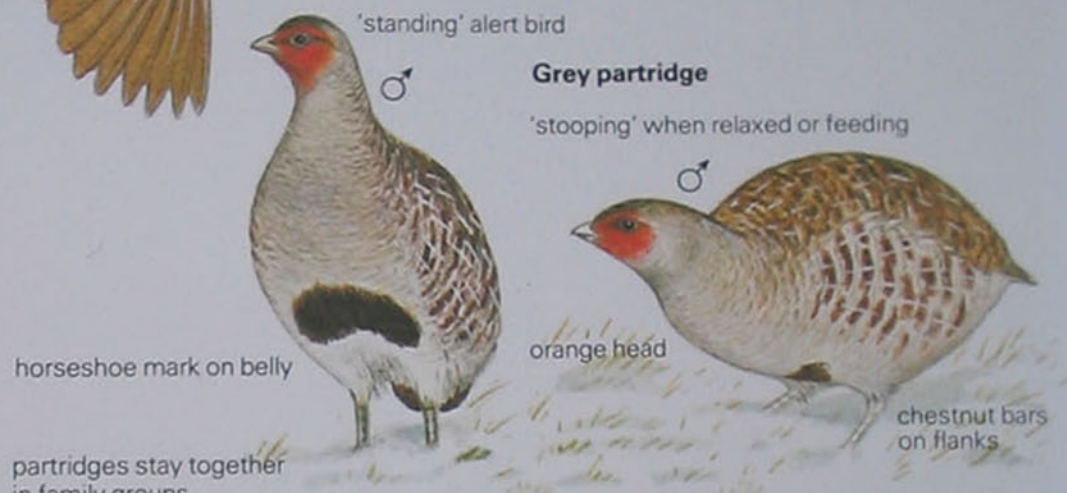
Farmland birds Both species of partridge are birds of mainly open country with patches of cover. Thus much of our agricultural land suits them ideally. In its home area in Europe the red-legged partridge is accustomed to dry conditions, and in Britain, too, it seems to prefer drier regions, being particularly numerous in the eastern parts of England. The grey partridge, on the other hand, is widespread in England, Scotland and Wales, except for the most mountainous areas; its habitat extends to some areas of moorland.

A wide variety of farmland is occupied by partridges, for grassland, cereals, root crops and fallows all provide these birds with their various food needs. Partridges are generally

Common partridges



Left and below: The grey partridge has a mottled brown back, black bill and legs, and a rufous brown head. The red-legged partridge lacks the mottling on its greyish-brown back, and has a bright red bill and legs. It also has vivid head markings: a grey forehead shading to a chestnut crown, a white eyestripe, and a creamy brown chin. It also has a black line across the throat and up to the eyes; this black extends below the neck in the form of black spotting.



fairly reluctant to fly: they would sooner run to avoid danger, and therefore low vegetation, permitting ready escape as well as good visibility to allow detection of impending danger, is preferred.

Nest-building For breeding, however, more cover is required. The nests of both species are usually built on the ground and, while the red-legged partridge builds in vegetation sheltered by a bush or tussock, the grey partridge is more demanding, nesting in thick vegetation, often in a hedge bottom or at the edge of a plantation. The nesting behaviour of the two species is very different for, while the female grey partridge builds her own nest, the red-legged partridge's nest is built by the male. In fact he builds several nests, of which the hen selects one. The cock may then build a second nest after the first clutch is complete, the eggs in each clutch being incubated at the same time.

The young chicks In both species the eggs are incubated for about 24 days and, since incubation does not begin until the last egg of the clutch has been laid, all the eggs hatch on the same day. The downy chicks are able to feed themselves soon after hatching but they are brooded by their parents to keep them warm during their early days of life. In the grey partridge, which only ever has one brood, both parents share the parental duties, as do red-legged partridges with single broods. However, with pairs that lay two clutches, each clutch is brooded by one parent.

The chicks develop rapidly and are able to flutter off the ground when about 10 days old and can undertake short flights at around 15 days, but they do not become fully grown until they are at least two-and-a-half months old. Even then they stay with their parents in family groups, called coveys, until they become independent in the late winter or early spring following their hatching.

Ground-nesting birds are particularly prone to predation, and partridges are no exception. Foxes, stoats and cats take their share, as do various members of the crow family. Mortality of the chicks varies considerably from year to year; it is particularly high in cold and wet seasons, when parents

tend to desert their broods and the food of the chicks is in short supply. This highlights one of the hazards the chick faces on starting to fend for itself so early in life. For a while a coat of down makes a good layer of insulation when it is dry and fluffy, but once it becomes wet it offers virtually no protection against the cold. Rain can therefore be fatal, and if food is scarce, so that a downy chick has to spend more time feeding and less time being

Above: A grey partridge, discovered by a stoat (out of the picture) adopts a threatening pose to scare the animal away. Fanning its tail, it displays the vivid chestnut colouring on its tail and flanks.

Above: A red-legged partridge walks in a meadow full of wild flowers and ripe seeds. The seeds once formed a good third of the diet of both species, but have dwindled to a mere 4% as the weeds have disappeared with the use of herbicides. Now the partridges eat cereal grains in much greater quantities.

Below: The red-legged partridge is found mainly in the drier eastern parts of England; the grey partridge is more widespread.

brooded by a parent, it is much more likely to get wet.

Seed eaters The adults of both species eat mainly plant material, especially leaves, seeds and roots but, while the red-legged partridge tends to dig for its food with its bill, the grey partridge picks its food from the soil surface. The diets of the two species are very similar and certain weeds, such as chickweed and bindweed, are important to both. As weeds have become less prevalent with the use of modern herbicides, the birds have taken to eating more cereal grains.

Insect eaters But it is when we consider the food of the chicks that we see how some birds find it difficult to adjust to new agricultural methods. In their first few days of life, chicks need a plentiful supply of insects, which presumably nourish them with the protein that they need for their rapid growth. During this period up to half the chicks' diet can consist of insects; some kinds of insect are avoided while others are obviously preferred. At present, the insects most commonly eaten are the bugs, weevils, caterpillars and aphids that the chicks find in cereal and grass fields.

But changes have occurred in the kinds of insect that the chicks can find and in the numbers that are available to them. For example the larvae of a particular weevil that were eaten 50 years ago are no longer available because the plant, sainfoin, upon which the larvae fed, is no longer abundant. In fact, the number of insects generally present on intensively cultivated agricultural land has fallen due to various changes in farming methods, so that partridges no longer have the quantities of insect food that they were able to obtain 50 or more years ago.

On the decline Inevitably, the number of partridges has declined. The British Trust for Ornithology's Common Bird Census has shown that, since it began in 1962, the numbers of both species have undergone nearly parallel fluctuations; the decline in partridge numbers, which in fact already began in the 19th century, has affected the grey partridge much more than its introduced relative. This is probably due to subtle differences in such matters as where the birds feed, what they eat and when they breed–grey partridges breed earlier than red-legged partridges, and the former are less able to breed successfully in late springs, of which we have had so many in recent years.

Despite their decline in numbers, which has thus been caused by climatic as well as agricultural change, the grey partridge is still widespread and common, possibly numbering about half a million pairs in Britain and Ireland. The red-legged partridge, although it is helped by being bred in captivity and although it is well suited to our countryside, is less numerous than the grey, with an estimated 100,000 to 200,000 pairs in Britain, and none in Ireland.

CORALS: MARINE 'FLOWER' ANIMALS

Although most corals inhabit tropical seas and form the major part of coral reefs, a few species are found around the British Isles. Like their close relatives the sea-anemones, some corals bear a superficial resemblance to flowers.

Above: *Alcyonium glomeratum* is one of the soft corals found below the low-water mark around the British Isles. It is distinguished from *A. digitatum* by its more slender, more numerous fingers. It is typically blood-red.

The word 'coral' is used to describe several related groups of animals within the phylum Coelenterata. Until recently sea-anemones were the coelenterates which had received the greatest attention since they are the most easily found, occurring in shallower waters than corals. However, the growth of SCUBA diving has stimulated interest in British corals and provided new information.

Almost all corals are colonial, comprising numerous individuals called polyps–each resembling a small sea-anemone–attached to a common skeleton. According to the type of coral, the structure of the skeleton varies in composition from calcareous, through keratinous (horny), to one with a fleshy nature in which limestone spicules are embedded. The skeleton gives the colony its overall shape.

A few species of coral are solitary, consisting of a single anemone-like polyp sitting on a hard skeleton. Corals remain fixed in one place as adults, and are thus less mobile than the sea-anemones, which can creep slowly about when necessary.

Although an individual coral animal closely resembles a sea-anemone, in some species it may be very small–only about 1mm in height. It has a cylindrical body with a mouth at one end leading into the body cavity. A ciliated groove (lined with fine hairs) directs a current of water into the cavity, providing oxygen and inflating the polyp by hydrostatic pressure. The body cavity is divided inwardly by par-

titions called mesenteries. The mouth is surrounded by a ring of tentacles which are used for catching prey and which can be retracted at the onset of danger.

Attack and defence Like sea-anemones and jellyfishes, corals are well supplied with stinging cells (called nematocysts), particularly on the tentacles. When these are touched, an elaborately coiled, often barbed, thread shoots out, penetrates the prey and injects a poison. In addition to the stinging cells being used to catch the small invertebrates and plankton on which corals feed, they may also be used for defence.

There are no corals poisonous to man in British waters, but in tropical waters care has to be taken to avoid touching the stinging fire corals, which can inflict a painful rash. A few species of coral have non-poisonous threads which ensnare prey by their sticky nature.

Coral reproduction Coral colonies increase in size by budding off new polyps. Corals can also reproduce sexually. In sexual reproduction eggs and sperm are released from the polyps into the sea where fertilisation takes place. A ciliated larva is produced which swims freely for a short time before settling on the sea bottom and developing into a new polyp. This buds repeatedly to form further polyps, and the bases of the polyps secrete the skeleton.

Types of coral There are two main groups of coelenterates containing corals. One group, the octocorals, includes the soft corals, the tropical precious corals used in jewellery, and the horny corals or sea fans. They are nearly always colonial and have small polyps characterised by eight pinnate or feathery tentacles.

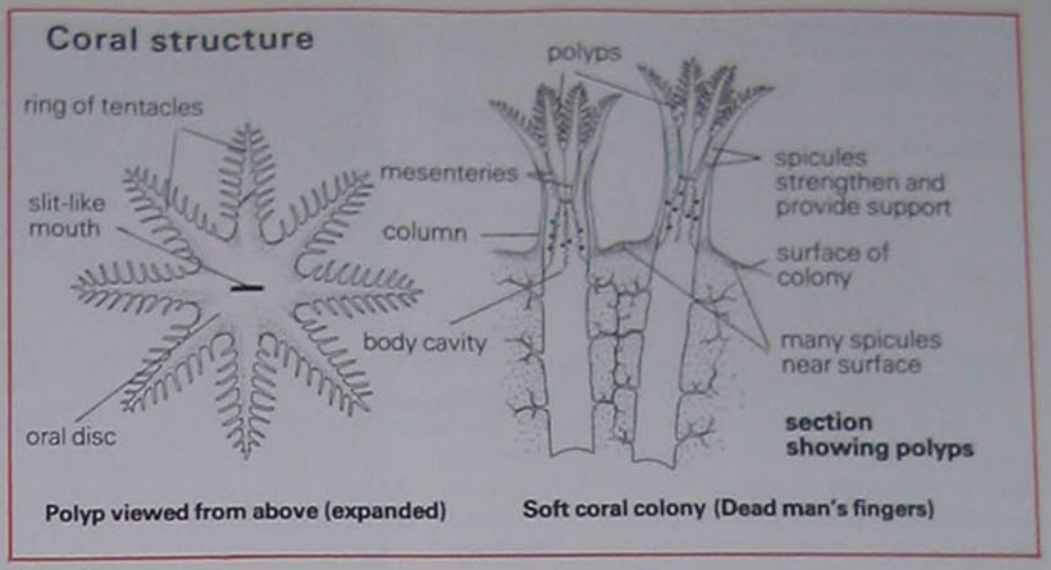
The soft corals have no continuous, solid skeleton. Instead, they have limestone spicules embedded in the soft living tissue secreted by the polyps. The precious corals and the horny corals have skeletons of limestone or a more flexible horny material.

The second group, the hexacorals, includes black corals (the tropical semi-precious corals used in jewellery), and the true stony or reef-building corals. They have larger polyps with unbranched tentacles characteristically arranged in multiples of six, sometimes in large numbers. Although most species are colonial, there is also a number of solitary ones. They have a stony skeleton on which the polyp sits, and in tropical reef-building species it forms large branching or rock-like lumps of limestone.

Soft corals Like sea-anemones, soft corals sometimes occur locally in British waters in huge numbers. The best known is dead man's fingers (*Alcyonium digitatum*), which bears a passing resemblance to its common name when washed up dead on the beach. Under water, however, the fleshy projections are very colourful, varying from white to yellow, pink or orange. The feathery tentacles may be about 10mm ($\frac{1}{2}$in) in length. *A. digitatum* is often found attached to pier supports or to rocks in sheltered places on the lower shore around most of the British Isles. Colonies reach about 12-20cm (5-8in) in length.

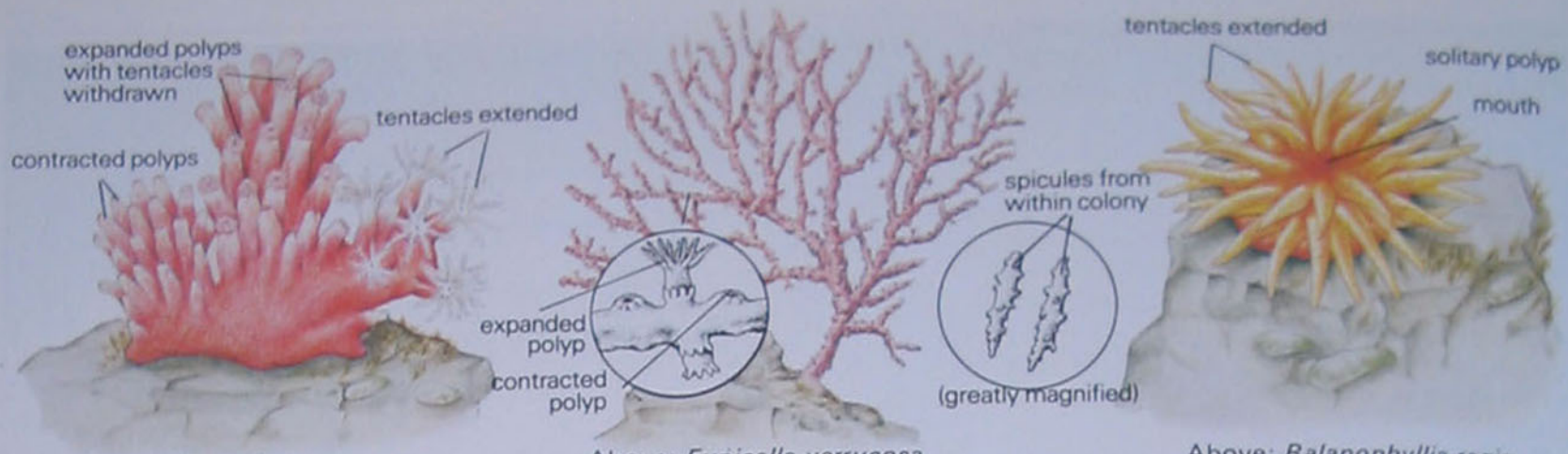
Two other soft corals are found around the British Isles but they are limited to just a few places and occur only below the low-water mark. *Alcyonium glomeratum* is distinguished from *A. digitatum* by its relatively slender and more numerous fingers; it is typically blood-red or rust-coloured and only occasionally pale orange or yellowish. Large colonies reach 50cm (20in) in size. It is found only in sheltered, dark sites–usually quite deep (10-50m or 5-25 fathoms)–on the south and west coasts of the British Isles, notably in the waters of Devon and Cornwall, but also as far north as the coast of mid-west Scotland.

Parerythropodium coralloides, the second soft coral, is a species found mostly in the Mediterranean and on the west coast of France, but it also occurs locally on the west coast of Britain as far north as the Isle of Mull, occasionally in large numbers. It has small lobes and resembles species of *Alcyonium*, but



Above: Individual coral animals are known as polyps. Each polyp has a mouth at one end leading into a body cavity divided by mesenteries. The polyps of colonial corals, such as these, are linked to each other. The mouth of each polyp is surrounded by a ring of tentacles which are used to catch prey.

Below: The Devonshire cup coral (*Caryophyllia smithii*), with the polyps expanded. This species is comparatively common on the west coast of the British Isles as far north as Shetland and Orkney. The Devonshire cup coral is solitary, with each polyp resting on its own cup-shaped stony skeleton rather than being connected to other polyps.



Above: *Parerythropodium coralloides,* a colonial soft coral.

Above: *Eunicella verrucosa,* a colonial sea fan.

Above: *Balanophyllia regia,* a solitary coral.

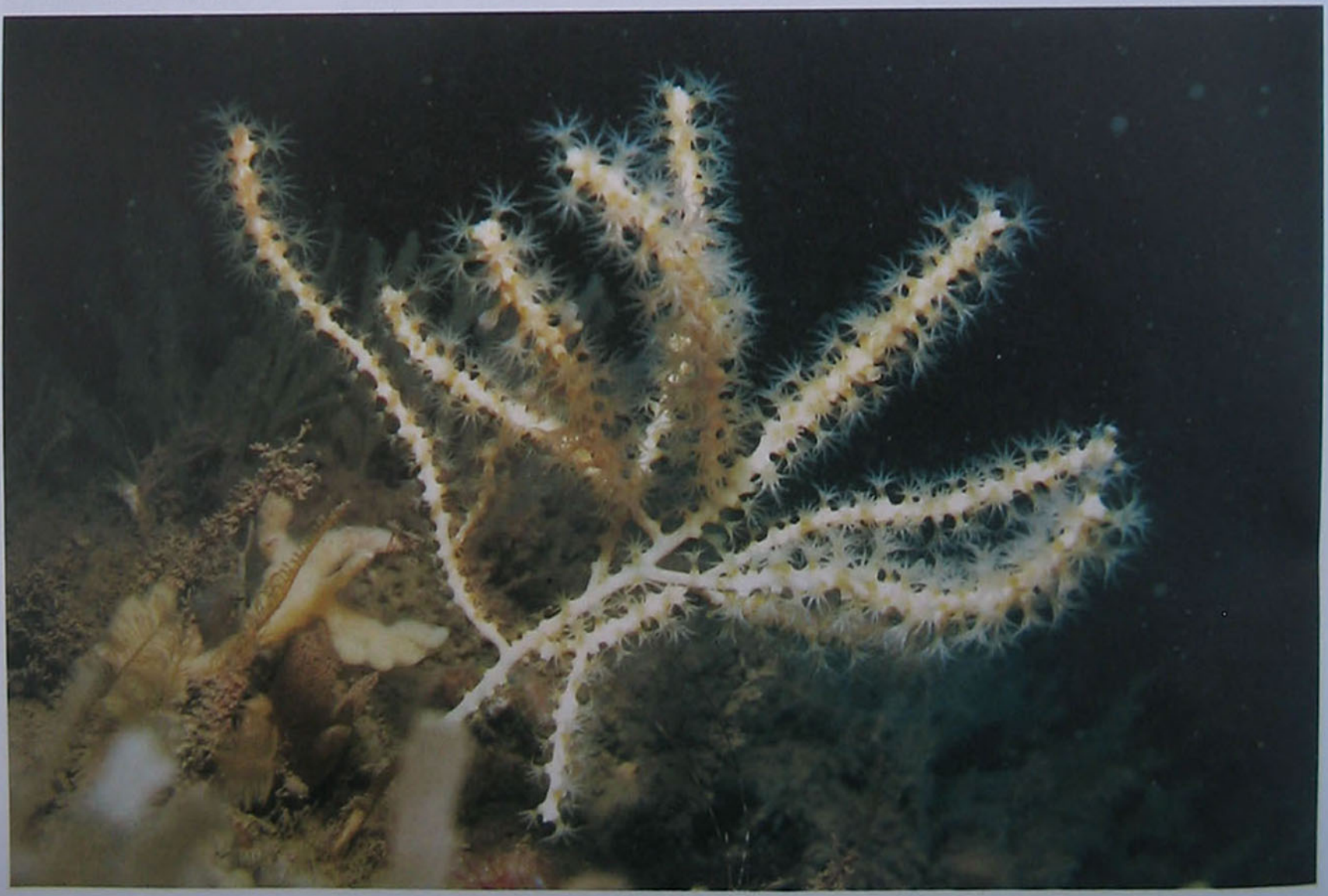
Below: *Swiftia pallida* is one of the only two sea fans (horny corals) known in British waters. The colony grows in one plane—hence its name—with the flat surface facing the current so that there is a maximum area for catching food borne by the current. The sea fans have a horny internal skeleton which grows in a branching fashion, with the polyps sited along the branches. *S. pallida* is found on the west coast of Scotland at depths of 18-60m (60-200ft).

it often grows as an encrustation on rocks, usually in deep water. Its colour varies from white to deep red, but most British specimens are pale pink, often with a ring of white on the polyp just below the tentacles which gives the colony a spangled effect.

Sea fans Sea fans or horny corals differ from soft corals in having a horny internal skeleton which grows in a tree-like branching fashion and is fastened to a rock or some other firm surface. The polyps grow along the branches. The colonies grow in one plane—which is why they are also known as sea fans—and the flat surface generally faces the prevailing current so that there is a maximum area for catching food. Only two sea fans are known in British waters, *Eunicella verrucosa* and *Swiftia pallida*.

The better known of these is *E. verrucosa* as it is often collected, either for decorating marine aquaria or as a souvenir. When dried and mounted it makes an attractive ornament. It grows at depths of 20-100m (10-50 fathoms). Colonies reach about 30cm (12in) in height and branch profusely in one plane, although bushy forms are also sometimes found. On the west coast of Britain both pink and white colonies are found, but on the south coast colonies are pink.

The second sea fan, *Swiftia pallida*, is found at several sites on the west coast of Scotland at depths of 20-60m (10-30 fathoms). It is



Precious corals

The corals used for making jewellery belong to the genus *Corallium* and are well known for their spectacular delicate red or pink skeletons. *C. rubrum*, the species found in the Mediterranean, has been collected by man since the Neolithic period some 5000 years ago. Although its most important use has always been for jewellery and decorative purposes, the Romans used to grind it to a powder which was taken as medicine, and in the Middle Ages it was believed to possess various magical properties. Corals grow very slowly, and as a result Mediterranean coral, especially, has been drastically over-collected. It is now found only at great depths—more than 50m (160ft)—in such places as off the coasts of Tunisia and Sardinia. Most of the coral used in jewellery today comes from the Pacific Ocean, and it is collected and carved with great artistry and skill by the Japanese and Taiwanese before being sold all over the world.

usually whitish or pale grey and the colony is smaller and less branched than *E. verrucosa*.

In the more popular SCUBA diving areas—all around the Scilly Isles, for example—*Eunicella verrucosa* has been rather badly over-collected in the past, but scientists now think that the populations may be recovering at last, since divers are being discouraged from collecting these attractive corals as marine curios.

Stony corals Unlike tropical species, no British stony corals form huge intertidal reefs, and they are mostly solitary and seldom branch. One of the better known species, the attractive Devonshire cup coral (*Caryophyllia smithii*), is comparatively common on the west coast as far north as Shetland and Orkney. Unlike most stony corals, it is solitary (the polyps are not connected to each other), and it closely resembles sea-anemones, apart from the fact that the polyp sits on a cup-shaped stony skeleton. Several polyps may be found on one rock. They have up to 80 translucent tentacles varying in colour from brown, red, orange or pink to white, or a vivid emerald green. The tentacles have many stinging cells, and end in white knobs. When the soft parts are withdrawn, the skeleton, about 1cm (½in) high, can be seen with its radiating septa (walls).

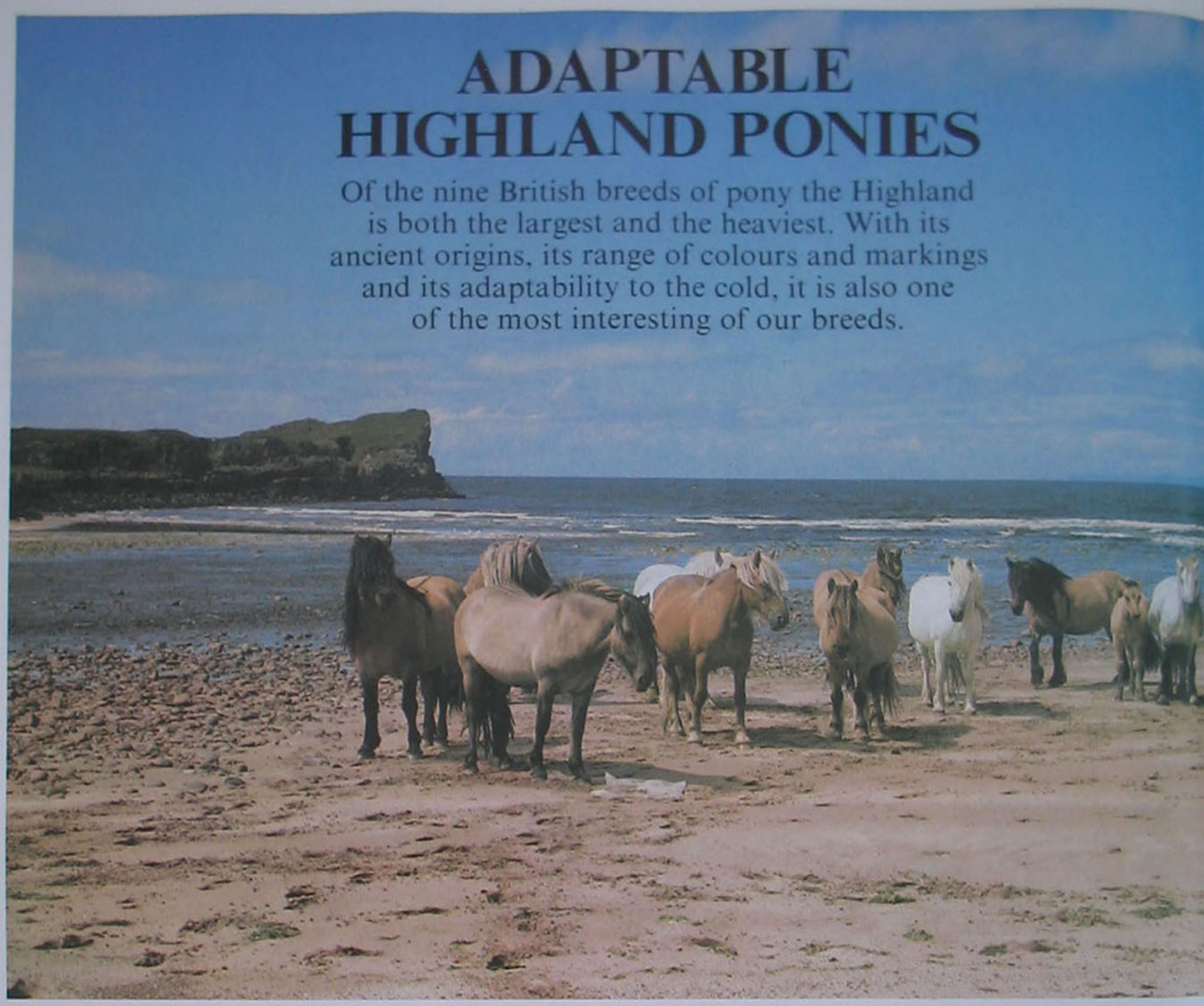
Different forms of Devonshire cup coral are found at different depths. The shallower water form is found attached to rocks, shells and worm tubes in shaded places and deep pools down to about 100m (50 fathoms) and it has a more or less cylindrical coral skeleton. The deep water form occurs down to about 1000m (500 fathoms) and has a coral cup in the form of an inverted cone with a narrow base.

The attractive scarlet and gold star-coral was first discovered in a rock pool near Ifracombe by the Victorian naturalist Philip Gosse who named it *Balanophyllia regia* because of its royal colours. Young specimens have a yellow body with yellow tentacles, but as they age they become progressively redder until they attain the rich scarlet colour found in adults. It has up to 48 tentacles without the terminal knobs of the Devonshire cup coral. The skeleton also differs in that it is finely perforated and the radiating partitions show a distinct six-rayed effect. The scarlet and gold star-coral is not very common, being found only below low tide level to about 25m (13 fathoms), attached to rocks in caves and gullies in the extreme south-west off the coasts of Devon, Cornwall and Dyfed.

Above: Dead man's fingers (*Alcyonium digitatum*), shown here with tentacles retracted. It is sometimes found in large numbers in the shallow waters off the coast of Britain. The common name derives from the coral's appearance when it is washed up dead on the beach with the knobbly projections and feathery tentacles no longer attached. The example pictured below shows the variable colour of this species. Here, the tentacles are fully extended.

ADAPTABLE HIGHLAND PONIES

Of the nine British breeds of pony the Highland is both the largest and the heaviest. With its ancient origins, its range of colours and markings and its adaptability to the cold, it is also one of the most interesting of our breeds.



Above: A herd of Highland ponies living on the remote and unspoilt Hebridean island of Rhum.

HIGHLAND PONIES
Size 13-14.2 hands (132-147cm/52-58in).
Colour Grey, brown, and various different shades of dun.
Breeding season Spring and early summer.
Gestation Approximately 11 months.
No of young Normally one. If twins are born, one very often dies.
Life span 20-30 years.
Food Grasses, gorse, some seaweed if available for essential minerals.
Distribution Scottish Highlands and Western Islands.
Breed Society Highland Pony Society.

Although there are variations in height and size, the typical Highland pony presents a solid, powerful and compact appearance, with noticeably sturdy legs. In the wild, or when it is turned out for the winter, the most prominent features are the long, thick forelock which reaches from the top of the head sometimes right down to the muzzle, the profuse, almost curtain-like mane of slightly wavy hair, and the thick, bushy tail.

Many colours In addition to the common greys and browns, the Highland's colours include a remarkable variety of duns, described as mouse, yellow, grey, golden, cream and fox. There are also a few liver chestnuts, made spectacular by silver-grey manes and tails. The original colour is believed to have been yellow dun; when this colour is examined closely, it is clear that the individual hairs are black at the roots, becoming progressively lighter until they are golden at the tips. This gives an impression of bright gold which contrasts attractively with the dark ear tips, and dark face, mane and tail.

Many of today's stud-bred ponies are grey, said to be largely due to the prepotency of one stallion, Herd Laddie, foaled in 1881. This magnificent grey stood at the Duke of Atholl's stud until his death in 1910. His influence on stud-bred ponies has been enormous, and most of the present-day animals trace back to him.

Perhaps even more interesting than the colours is the existence in most ponies of a dark dorsal eel stripe; many also have zebra-like dark stripes on the inside of their forelegs. These suggest the Highland's links with the primitive ponies of northern Europe, and similar marks are found in some modern northern European breeds.

Ancient origins The Highland's northern European origins are generally accepted, but ponies, albeit of smaller stature than the present ones, have been in Scotland for many thousands of years, as fossil remains some 60,000 years old indicate. With the coming of man and when sea communications were sufficiently advanced, the indigenous ponies were subjected to infusions of outside blood, including that of Arab, Percheron, Clydesdale

and Norwegian horses.

Because the ponies were widely scattered through the Highlands and Western Islands, the same influences did not necessarily affect the breed as a whole. For instance, the ponies of Barra were probably influenced more than some others by Arab blood, due to the presence of Arab stallions within that comparatively small area. The result was lighter, rather more refined ponies. On South Uist a Clydesdale stallion was used which produced a heavier type.

In general, too, the environment on the smaller islands has influenced the ponies. There are few, if any, trees, and little other shelter. A constant on-shore wind makes heat conservation even more of a problem, and ponies survive better if they have smaller bodies with less surface area from which to lose heat. Consequently, by natural selection, the ponies on such islands tend to be smaller, while those on islands such as Skye, where there is more shelter, tend to be larger. This has also been encouraged to some extent by selective breeding.

Adaptations to the cold The Highland is well adapted to a generally harsh environment. The generous forelock gives the eyes protection from wind and rain when the pony is grazing, and the mane acts as a shield for the throat and neck, channelling much of the rain and also helping with heat conservation, particularly for the lengthy and superficially sited jugular vein, through which body heat can also be lost.

In common with other breeds, Highland ponies normally stand with their backs towards bad weather and the abundant tail hairs blow between the legs, giving protection to the hairless inguinal region and the thinly covered inside surface of the thighs.

The extreme density of the winter coat, especially over the hind-quarters and back, acts as insulation and prevents snow, rain, and ice from penetrating to the skin. The

Above: A Highland pony mare on Rhum. Older mares act as leaders of the herd.

Below: On Rhum the Nature Conservancy Council protects the ponies. They live something approaching a 'natural' life, competing for food with other fauna on the island, and roaming over large areas according to the weather and the season. The breeding and foaling is not completely natural as the mares are brought to a stallion in the field and then kept close to the house for winter.

comparatively small amount of feathering around the fetlocks channels the rain and stops excessive wetting of the heels which could lead to irritating skin conditions. In summer the mane, tail and forelock give some protection from insects.

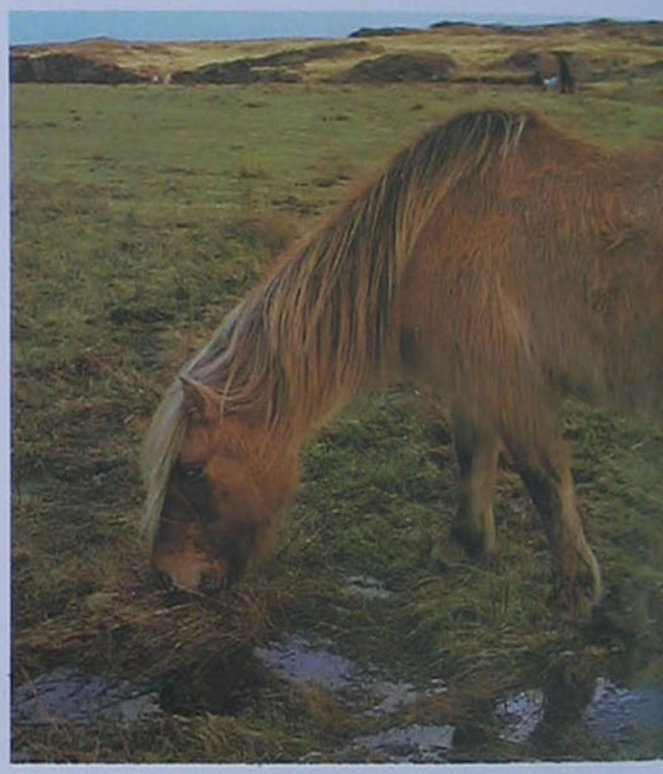
Front view The Highland pony, together with some of the other British and European breeds, has certain characteristics of eye and orbital positioning that differ from some other breeds and appear to be a direct adaptation to their environment.

In many breeds the eyes are set very much to the side of the head, giving considerable all-round vision, the only blind-spot being the width of the animal's own body. This means that they do not normally have binocular vision. This feature, combined with the structure of the eye, gives the horse rather poor forward vision, and it finds it difficult to

Above: A Highland mare and her foal. Like most mountain and moorland ponies, the Highland easily becomes overweight if it spends too much time in lush pastures without enough exercise.

Left: The head of a two-year old Highland filly. The eyes of Highland ponies are set rather more to the front and on either side of a slightly narrower nose than those of ponies which do not have to graze on rough terrain and herbage.

Below: Highland ponies are used as pack ponies to carry the carcases of red deer in the annual cull.



focus well on objects more than about 1.3m (4ft) ahead. When a horse manages to focus its eye on a close object in front, it cannot see clearly and it also loses its ability to see to the side and rear. The animal can compensate to some extent by moving its head and neck to one side or another.

Some breeds also have more prominent eyes which allow them more scope for visual accommodation, but for the Highlands and similar breeds which habitually graze among rough herbage, eyes of this type could easily be damaged by sharp twigs, thorns and the branches of trees.

It appears, however, that over the centuries the Highlands have undergone a structural adaptation of the position of the eyes and the proportions of the face to improve their forward vision. Although the eyes are still placed laterally, they are set rather more to the front on either side of a slightly narrower nose than those of breeds which do not have to graze in such rough areas. This gives a degree of binocular vision and better overall

Right: Highland ponies and cattle grazing together. On Rhum they also have to compete with red deer for food. To be sure of food the ponies are now returning to the 'inbye' fields near the house around February, and they are kept there until the first bite comes through at the end of April or the beginning of May.

Below: Highland ponies are well adapted to a wet and cold environment. They are safe, friendly and reliable to ride, and are often used for pony-trekking.

forward vision so the pony can focus more accurately on the ground in front and therefore feed more advantageously. The eyes are also set further down the head than in many other breeds, thus further improving the close-to-ground vision.

Working ponies There are not many Highland ponies still living under completely natural conditions; as in most other British pony breeds, the emphasis has moved to the private studs, but there is still a small herd of ponies on the Isle of Rhum.

Here they are primarily used as working animals, being used as pack ponies to carry the carcases of the red deer that have been shot in the annual cull. This is one of the traditional tasks of Highland ponies, many of which are strong enough to carry a 111kg (16 stone) stag across the rough, steep terrain of the Highlands and Islands.

On Rhum three-year old ponies are introduced to deer-carrying by first being given a trial run with weighted sacks smeared with blood, so they will not be upset when the real thing is slung across their backs. They are then used to carry hinds, which are lighter than stags. The following year they are expected to work for the whole hind season, after which they carry stags. There are two short culling seasons: late July until mid-September, and late October until Christmas. Six ponies are shod and used for each period and then turned out on the hill.

In general the breeding life of Highland ponies differs little from other native breeds in their natural habitat. On Rhum the herd (apart from the breeding mares) is turned out for most of the year. The animals roam between Harris on the south-west coast and Kilmory on the north–about five miles. At Kilmory on the machair (grassland behind the sand dunes) there is good grass on land that was formerly cultivated by crofters, and the ponies go there in spring for the 'early bite'. At other times they eat grass, chiefly *Agrostis*, a little *Molinia*, and seaweed for important minerals including iodine.

As the stallion is never turned out with the mares, the herd structure remains much the same all year, instead of the male being the leader during the breeding season. The older mares act as leaders; when a few of them were removed several years ago, the pattern of seasonal movement was disrupted and has not yet been fully re-established.

For centuries Highland ponies were used by crofters as all-purpose animals. Today they are popular riding ponies, notably for pony-trekking.

Adaptations for survival

HARDY MOUNTAIN PLANTS

Despite being so exposed, mountain plants form thriving communities, even where the ground is covered by snow for much of the year.

Above: *Diapensia lapponica* is something of a mountain rarity. Properly an Arctic species, its tiny white flowers are found on only one mountain in western Scotland.

Below: Alpine lady's mantle (*Alchemilla alpina*) has a covering of silky hairs on the underside of its leaves which helps to protect them from the water of melting snows. In flower from June to August, it is seen here on Ben Lawers in the Grampians.

One factor that makes mountain plants so interesting is the number of different habitats to be found within a relatively small area. Cliff ledges, screes and damp gullies all have very different communities of plants and these in turn may vary according to altitude or aspect.

Snow patch plants A quite distinctive association of species is one that surrounds late-lying snow patches that often persist into late summer, especially in a summer following a very cold winter. The centre of such a patch might remain snow-covered throughout the year, or be uncovered for a few weeks only. Surrounding it are a series of definite zones, each with a characteristic flora. The species growing in the innermost zone may be uncovered–and so free to grow and photosynthesise–for only two or three months each year; only a few species of liverworts can grow in these conditions. In the next zone, where plants may be uncovered for three to four months per year, mosses such as *Polytrichum norvegicum* may be found, together with the fir clubmoss and a few cushion-forming alpines, such as the starry saxifrage.

Acid and alkaline soil dwellers The outermost zones surrounding the snow patch provide a home for several interesting species of flowering plants. One of these is the least cudweed. This tiny, tufted species is a member of the daisy family, somewhat resembling edelweiss, to which it is distantly related. Its woolly leaves are densely covered with tiny hairs, which help to keep it dry when the snow melts, and it produces small, compact spikes of whitish flowers with papery brown bracts in July. The least cudweed is especially characteristic of late-lying snow patches but requires acid conditions and is found only on the acid granites of the Cairngorms and Skye.

On the Cairngorms it may be found growing alongside Alpine lady's mantle. In the Cairngorms Alpine lady's mantle is most common in snow hollows which, being sheltered, have better-quality and more abundant soil than the surrounding areas.

Many of the species that grow around snow patches flourish regardless of the soil type. Sibbaldia is one such species. It belongs to the rose family, like the Alpine lady's mantle, and is a small, compactly tufted plant with blue-green leaves and tiny yellow-petalled or petal-less flowers.

A very different species of the outermost snow patch zone is one of the mountain sedges–stiff sedge. It has narrow recurved leaves which grow from a creeping rhizome and flowers that are typical of the sedges. They are purple-black in colour and upward-pointing with brown bracts; the female flower spike is below the male. Stiff sedge often grows alongside such grasses as the wavy hair grass (in acid conditions) and Alpine meadow grass, and a shrub, the least willow. This is the smallest of Britain's wil-

lows, forming prostrate mats of woody, creeping stems with bright green leaves.

Colonizers and pioneers Snow patches are only one of many micro-habitats on our mountains. Screes and patches of bare, stony soil, freshly formed from the mountain rocks, provide a home for many plants that demand an open situation where they are not shaded out by other species. The pioneers, or colonizing species, of the mountains are particularly demanding in this respect; one such species is *Koenigia islandica*.

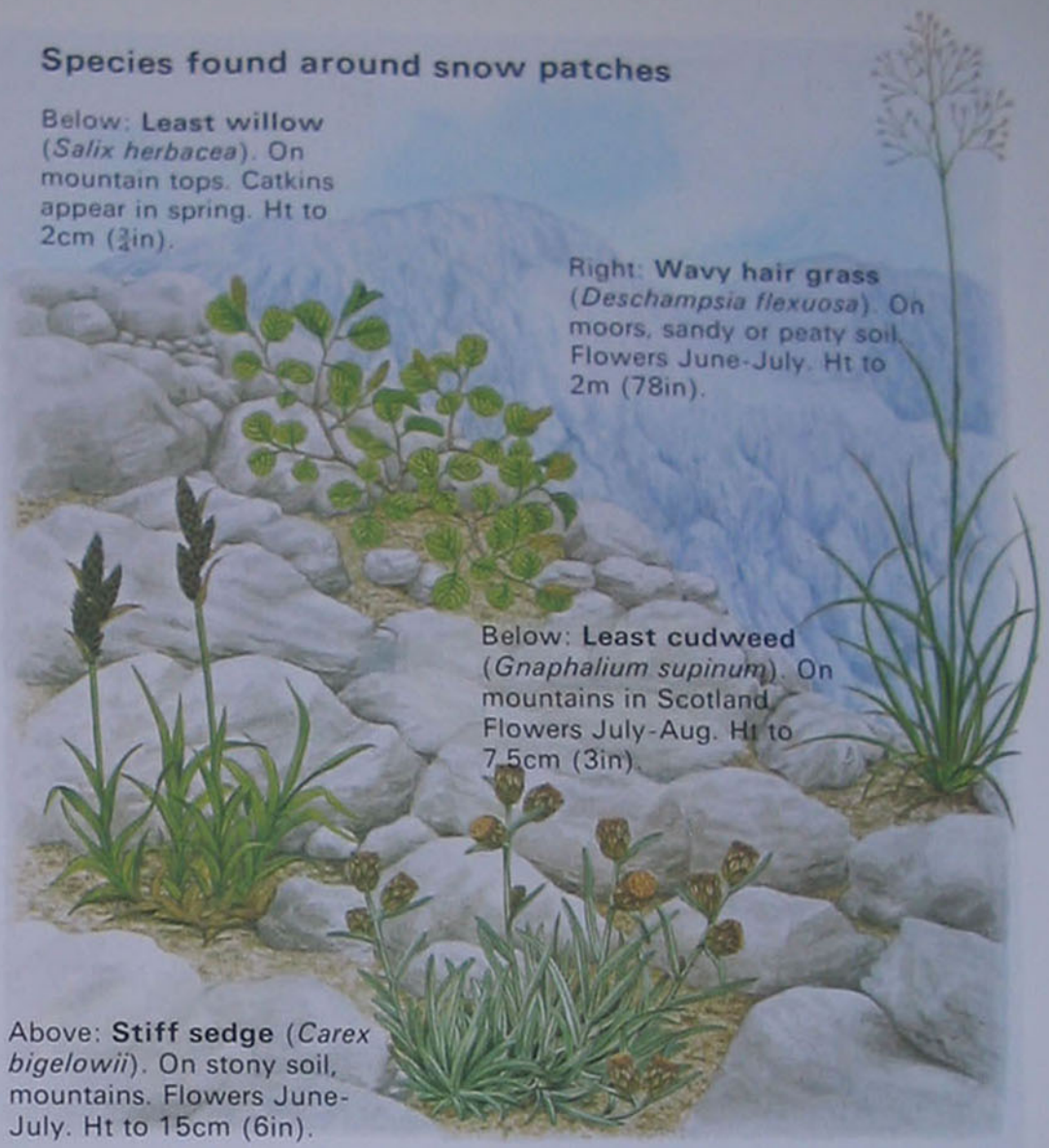
A tiny plant, with small yellowish-green flowers that appear in summer, it often grows alone, covering large areas of the bare, stony soil. It is an unusual species in several ways. Firstly, it is an annual, whereas most mountain plants are perennials. Secondly, it is very limited in its British distribution, growing only on certain mountains on the islands of Skye and Mull, although other habitats suitable for its growth are found on other mountains. Thirdly, it was not discovered in Britain until 1934 and even then it was wrongly classified, being classified properly only as recently as 1950.

Diapensia lapponica is another relatively recent discovery, being found on a mountain ridge near Fort William in western Scotland in 1951. Here it grows on a patch of quartzite rock which is very different from the surrounding schist forming the rest of the ridge. It forms perennial compact cushions with leathery, evergreen leaves and white flowers which appear in May and June.

Species of the lower slopes Large areas of Britain's mountains–such as the acid granite of the Cairngorms and the sandstone of the Pennines–are sometimes considered rather dull from a botanical viewpoint. However, they are often covered by wide expanses of heather, bilberry, cowberry, crowberry and other dwarf shrubs that are adapted to living in acid conditions. Where the rainfall is very high or drainage is poor, layers of peat may accumulate over a long period of time. If these layers are very thick, the composition of the underlying rock ceases to influence the vegetation. Also, on heather moors there may be outcrops of less acid rock above ground, like the thin bands of limestone which occur in the sandstones of Ingleborough and Penyghent.

These limestone bands provide a home for many interesting montane species, including several saxifrages, of which the most attractive is probably the purple saxifrage. This is a mat-forming perennial with solitary, rosy-purple flowers borne at the ends of the flower stems in March and April. By way of contrast the yellow mountain saxifrage produces red-spotted yellow flowers at the ends of erect rosettes in the spring, while Dovedale moss, a mossy saxifrage with larger rosettes, resembles some garden saxifrages. Its flowering shoots, which are about 15cm (6in) high, bear pure white flowers from April to June.

Species found around snow patches



Below: **Least willow** (*Salix herbacea*). On mountain tops. Catkins appear in spring. Ht to 2cm ($\frac{3}{4}$in).

Right: **Wavy hair grass** (*Deschampsia flexuosa*). On moors, sandy or peaty soil. Flowers June-July. Ht to 2m (78in).

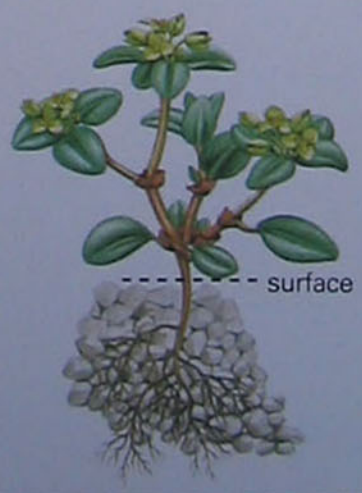
Below: **Least cudweed** (*Gnaphalium supinum*). On mountains in Scotland. Flowers July-Aug. Ht to 7.5cm (3in).

Above: **Stiff sedge** (*Carex bigelowii*). On stony soil, mountains. Flowers June-July. Ht to 15cm (6in).

Right: Sibbaldia (*Sibbaldia procumbens*) is a member of the rose family. A small, creeping plant, it produces tiny yellow-petalled or petal-less flowers in its leaf axils from July to August.

Below: *Koeniga islandica* is rather an unusual species to find on mountain tops, for it belongs to the Polygonaceae, a family more often associated with wet lowlands than inhospitable mountain ridges.

Strange find



A TALE OF TWO CITIES

You might imagine the wildlife of one city to be like that of any other, but this is not so – there are surprising regional differences, as can be seen in London and Birmingham.

Above: The artifical lake overlooked by Birmingham University's Halls of Residence. The plants you can see are great hairy willowherb and Canadian golden rod. Dabchicks breed on this lake, but do not appear in London except as visitors. The mallard (below) is far more numerous in London than it is in Birmingham, and well-adapted to town life. In the spring it may be seen on almost any sheet of water, even on ornamental fountain basins and diminutive ponds.

City centres look rather alike when considered as plant and animal habitats, and you might not expect to find much variety in their wildlife. Careful examination, however, reveals a considerable amount of variation, not only in the species that occur, but also in the way they have adapted to environmental conditions. This can be appreciated even if we compare the fauna and flora of London and Birmingham, cities which are no more than 183km (113 miles) apart.

Exceptional sites To make a reasonably fair comparison it is necessary to examine a small area near the centre of each city – both places are too vast to be considered in their entirety. London has places like Wimbledon Common and Hampstead Heath, which are hardly typical of the urban scene, while Birmingham's administrative boundaries now embrace Sutton Park, much of which is still a delightful wilderness.

To simplify matters, we concentrate on a radius of 5km (3 miles) around Charing Cross in London and around the Bull Ring in Birmingham. Even within these limits there are parts of Birmingham which seem quite out of place in the normal British townscape. The most remarkable anomaly is Edgbaston Park, a private open space which includes a golf course, a large swamp-fringed lake, a bluebell-carpeted beech wood, and an area of wet woodland where the native alders and

willows mingle with bamboo, *Gunnera* and other exotic species. The park also has an impressive bird list–tree sparrow, willow tit, reed warbler, kingfisher and ruddy duck have all nested there in recent years.

Rivers and canals There is nothing like Edgbaston Park in or near the centre of London. But then Birmingham has nothing to compare with London's great tidal river, and the former's naturalists will never see bottle-nosed dolphins or common seals swimming through their city. These and other marine mammals have penetrated the heart of London on rare occasions; in 1961, for instance, an unfortunate whale, a female lesser rorqual, was stranded at Kew. The Thames is now celebrated for its fish population, and is even clean enough for migrating salmon and sea trout. It is hard to believe that in the 1950s the metropolitan section of the river was completely deoxygenated and lifeless.

Birmingham has several small rivers and brooks. The largest of these, the Tame, is still badly polluted, but the improved condition of its other streams has attracted breeding kingfishers and grey wagtails. Central London's minor rivers have all been banished underground, and although grey wagtails have nested in the area–on buildings well away from water–the kingfisher is only an occasional visitor to London's lakes and canals.

Unlike London, Birmingham has an intricate network of canals which provide for plants and animals that are unable to establish themselves in the fast-flowing brooks. The city is linked with London by the Grand Union Canal, a branch of which meets the Regent's Canal at Little Venice, an idyllic spot where wildfowl share the tree-shaded water with the painted narrow boats; the occasional heron has even been seen on the towpath, stalking fish by lamp-light! It is a very different world from the Birmingham end of the GUC, which lies close to the motorway tangle of Spaghetti Junction.

Above: Canada geese at Swanshurst Park, Moseley. Many species of plants and animals are common to both London and Birmingham–for instance, the colourful displays of willowherb and Oxford ragwort on waste sites, Canada geese in the parks, grey squirrels looting litter baskets and even the occasional urban fox. But many of Birmingham's special plants and animals are associated with wetland habitats, which London has unfortunately lost.

Inner city ducks Water birds have a special fascination for bird-watchers, and the semi-captive pinioned ducks and geese in Central

Left: A familiar sight to all Londoners–a mass of pigeons perching in a London park. A much more unexpected ornithological feature in Central London, however, is its heronry. Grey herons, which have long nested in the London suburbs, have been frequent visitors to the central park lakes for many years, and they have even raided a goldfish pond on the roof of a Kensington store. In 1968 an inner city breeding colony was established in Regent's Park, only 4km ($2\frac{1}{2}$ miles) from Charing Cross. Although herons fly into Birmingham on fishing trips, there is no heronry nearer the centre than 19km (12 miles).
Black-headed gulls frequent both cities, but are much bolder birds in London: flying gulls may snatch tit-bits of food from the hand and, in St James's Park, even from the lips of those willing to try this unusual method of offering food. They will also occasionally perch on people's heads.

Above: One of the most impressive wildlife sights to be seen in Trafalgar Square as dusk falls on the city—thousands of starlings circling round and round, their twittering drowning out even the noise of the home-going traffic.

Below: A guide to some of the wildlife you can see within a 5km (3 mile) radius of Charing Cross and Birmingham's Bull Ring.

London's Royal Parks are of additional interest because of the wild visitors they attract, especially in winter. In severe weather the numbers of tufted duck in St James's Park have sometimes exceeded 2000.

Apart from the ubiquitous mallard, two species of wild duck breed regularly in the London parks. Pochard started nesting when pinioned birds in St James's Park paired with full-winged visitors in the 1920s. They have reared young in other parks in recent years, and the present population can be regarded as completely wild. Tufted duck have been breeding in London for over 60 years, but in Birmingham they have only been able to nest successfully in Edgbaston Park, where pochard have also bred, but not since 1866! These two ducks are seen mainly in winter in Birmingham, and never in vast numbers.

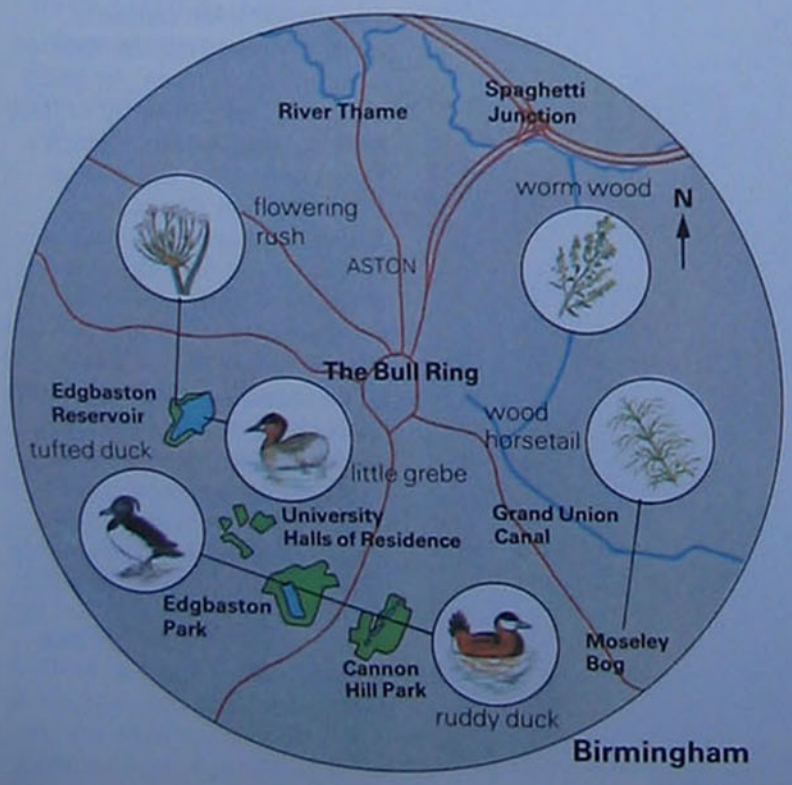
One bird which has yet to move into Central London is the North American ruddy duck—a charming addition to our fauna which started breeding in a feral state in 1960, after escaping from the Wildfowl Trust's collection at Slimbridge. It is firmly established in the West Midlands, and has been adopted as the symbol of the West Midland Bird Club. Ruddy ducks nested in Edgbaston Park in 1979 and again in 1980.

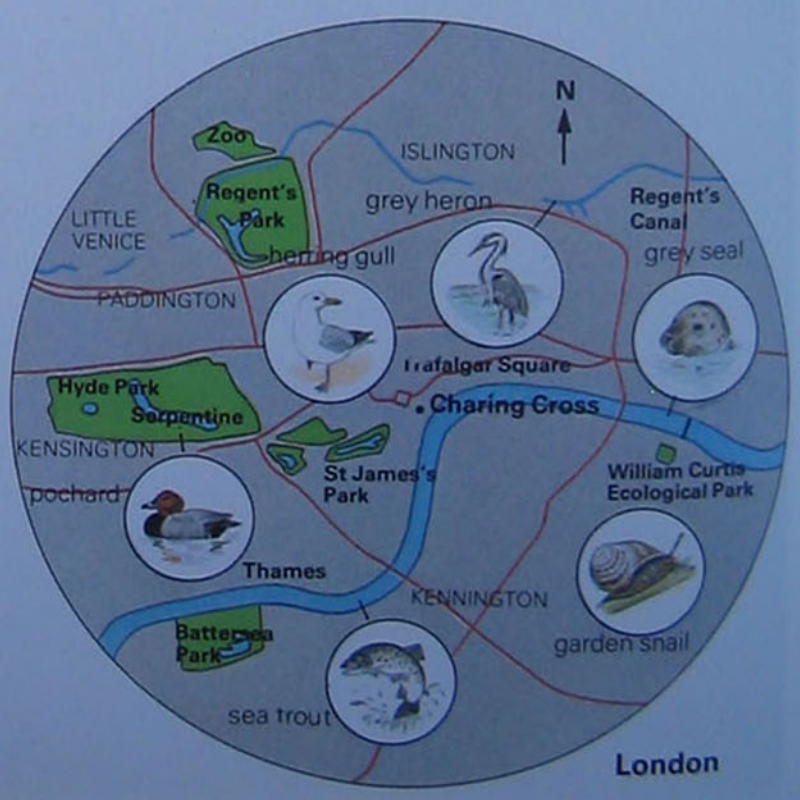
City gulls Of all the birds which have taken to urban life, the gulls deserve special mention. Not only may one species be more numerous in one city than another, but it may show differences in behaviour. Black-headed gulls, for instance, are thoroughly at home in both Birmingham and London outside the breeding season, but they are much bolder birds in London, not only jostling for bread with the park ducks, but feeding with the pigeons on office windowsills and in Trafalgar Square.

The so-called common gull (it is not as common as many other species), which freely associates with the black-headed gull in the London parks and often gathers in large flocks on the games pitches, is quite scarce in Birmingham. Even more unusual there is a summer record of an adult herring gull—yet London has a small breeding population of this species. Herring gulls have nested in some of the parks, on buildings at the Zoo and even on a rooftop in Whitehall.

Edgbaston Reservoir Built in 1826 as a canal feeder, this reservoir is now the centrepiece of a town park, with residential and industrial surroundings. Although it is used for angling, sailing and canoeing, about 130 species of bird have been recorded here over

Wildlife in the cities





the years, and it is one of the many places around the city centre where you will find frogs, now a great rarity in Inner London.

The reservoir has a particularly interesting shore-line flora, with marsh yellow-cress, water plantain, common spike-rush, trifid bur-marigold, gipsywort, celery-leaved buttercup, amphibious bistort and a fine expanse of flowering rush. Marsh plants rarely survive urban development, and most of these species have long since vanished from Central London.

Moseley Bog Another botanical site which has no Central London equivalent is the extraordinary piece of wet woodland known as Moseley Bog. Its surroundings are suburban rather than urban, but most of its small area lies within 5km (3 miles) of the Bull Ring.

Several treasures sought here by Victorian botanists – cranberry, grass of Parnassus and bog pimpernel – have unfortunately gone, and the one surviving royal fern may really be of garden origin, but this enchanted place still has species you could never hope to find in a built-up area. These include opposite-leaved golden saxifrage, yellow pimpernel, bay willow, wood horsetail and many others. Like many sites of scientific interest, Moseley Bog has an uncertain future, and a vigorous campaign has been launched to save it from development.

Distribution patterns The bay willow and wood horsetail of Moseley Bog would be of special interest to a visiting London naturalist, for these are plants with a mainly northern distribution. Birmingham is situated on what might be described as a biological watershed, where some species with a northerly range are approaching their southernmost limits, and where others, which are common in the south, are becoming scarce.

Other distribution patterns are harder to explain. Why should there be masses of grey, aromatic wormwood on West Midland waste sites, when the plant is so scarce in London? And why should Canadian fleabane have been absent from the bombed sites of Birmingham when it was so abundant in London after the air raids? It did, after all appear elsewhere in the West Midlands, in the ruined city of Coventry.

Acidity of the soil no doubt accounts for the scarcity of the larger species of snail, for these animals need lime for the growth of their shells. The common garden snail *Helix aspersa* seems to be absent from much of Birmingham, even where building rubble would provide it with the necessary calcium. The soil of London is also acid, but the snails were plentiful on two of the bombed City sites in the 1950s, and they have survived in the William Curtis Ecological Park, in the shadow of Tower Bridge, where they were deliberately introduced in 1978. These animals are indeed privileged – there cannot be many urban snail reserves.

Above: Rosebay willowherb and duckweed on a Birmingham canal basin – even in the heart of this industrial city such plants can flourish.

Opposite left: A pied wagtail perching on a park railing – this species, and the much rarer grey wagtail, can survive in cities but like to be reasonably near water. Another bird found in both London and Birmingham parks is the magpie, but it is only since 1971 that it has inhabited central London. It has long been a familiar sight in other British cities, and in Birmingham has even nested in front gardens bordering busy roads.

FOLK TALES: FORTUNE IN THE TREES

A rich harvest, a proposed marriage, illness, even death and diverse superstitions–all could once be 'read' in Britain's ancient trees.

The first inhabitants of the British Isles depended on trees for shelter, fuel and food. The tall trees of the forest and the wide-spreading branches of isolated trees must have inspired awe and admiration for their life-giving properties.

Many superstitions have been regarded as ancient beliefs handed down from generation to generation. However, research in the last 15 years or so has shown many customs and folk beliefs to be comparatively recent, despite the fact that it is often difficult to ascertain their exact origins and dates.

Whether ancient or comparatively modern, however, folk lore may reveal many insights into our attitudes to the environment. Because trees have always been an important part of our environment, many species are featured in folk beliefs.

Farmers' tips Some beliefs concern the traditional occupation of the country–agriculture. Trees were thought to yield valuable clues for the sower of seeds; a Herefordshire couplet, noted in 1856, advised:

When the elmen leaves are as large as a farden
It's time to plant kidney beans in the garden.

More widespread was the belief that barley should be sown when the blackthorn blooms:

When the blackthorn blossoms white,
Sow your barley day and night.

Trees were sometimes believed to indicate the best season for fishermen to go out, or a crop's yield. Fishermen living beside the River Wye would watch alder buds–locally known as *aul* for:

When the bud of the aul is as big as a trout's eye,
Then the fish is in season in the River Wye.

If the Herefordshire oak trees were in leaf before the ash leaves, it was believed that a rich hop harvest would follow. In north-west England it was thought that a 'sympathetic correspondence' existed between hazel nuts and the corn harvest–the scarcity or abundance of one indicating that of the other.

Romantic predictions Some trees were be-

Above: Glastonbury's Holy Thorn is one of the most famous trees associated with the early Christians in Britain. The Holy Thorn, a variety of the common hawthorn, flowers not only in the summer but at Christmastime as well, in honour of the birth of Christ.
According to the best-known tradition, the original Thorn grew from the staff carried from the Holy Land to Britain by St Joseph of Arimathea, the rich Jew who took the body of Christ after the crucifixion and deposited it in his own tomb. The staff, so the legend goes, miraculously took root and budded in Glastonbury–the place where Joseph found the first Christian church in Britain.

lieved to predict the future. Ash leaves, for example, that had an even number of leaflets – 'even ashes' – were often used by girls who wanted a glimpse of their future husbands. A Dorset girl would hold the leaf and say:

The even ash leaf in my hand,
The first I meet shall be my man.

She would then place it in her glove, and later on her breast:

The even ash leaf in my bosom,
The next I meet shall be my husband.

A suitable young man was expected to appear soon after this ritual.

In the 19th century in Devon girls would go 'crabbing for husbands'. Wild crab apples were gathered on Michaelmas Day, on 29 September, and arranged in the shape of prospective lovers' initials. On Old Michaelmas Day, on 10 October, the initials which were found to be the best preserved were thought to indicate the best prospects. In east Kent and other places, a woman who married late in life, or any philanderer, was said to have 'searched the orchard until she found the crab'.

Messages Early in the 19th century the Cheshire May Birchers would offer comments on their neighbours. On the eve of May Day they would leave small branches of various trees on doorsteps. Plum was left for those who were considered glum, nut for a slut, bramble for those inclined to ramble, gorse for whores, and hawthorn as a general compliment.

Above: Traditionally associated with Robin Hood, the Major Oak at Edwinstone in Sherwood Forest is over 400 years old. Aptly named, the tree stands at over 18m (60ft) high and has a massive trunk measuring 10m (33ft) in diameter.

Jack-in-the-Green from door to door
Capers along with his followers four.
As May Day mummers are seldom seen,
Let us all give a copper to Jack-in-the-Green.

The May Day figure, Jack-in-the-Green, a man inside a conical framework covered with foliage, was formerly considered by some people to be a very ancient symbolic representation of the universal Vegetation or Nature God, and by others a sacrifice offered in the spring rituals to the god to ensure a bountiful year ahead. Recent research, however, has shown that Jack is comparatively recent, appearing towards the end of the 18th century as part of the May Day celebrations enjoyed by urban chimney-sweeps and the young chimney boys.

Hawthorn was more commonly associated with ill fortune or death, many people believing that if hawthorn was taken indoors death would follow. Other white-flowered trees thought to be unlucky included lilac.

Ill-fortune The creamy-white flowers of elder, like those of the hawthorn, were also feared, and in the Fens people believed that if the scent of elder flowers was inhaled for any length of time a deep coma, resulting in death, would follow. It was believed throughout Britain that elder was the tree on which Judas Iscariot hanged himself, and so it was considered the unluckiest of trees – although the herbalist Mary Thorne Quelch, writing in 1941, quoted a gypsy friend: 'The healingest tree that on earth do grow be the elder, them sez; and take it all round I should say 'twas.'

One of the most beautiful English folk carols, *The Bitter Withy*, explains why willow trees rot and become hollow comparatively quickly. The child Jesus meets three highborn children and asks to play with them, but they reply that they cannot play with someone born in an ox's stall. Christ makes a bridge of sunbeams and walks over it, but when the other children attempt to cross the shimmering bridge, they find it will not support them and they drown. Their mothers protest to Mary, who punishes Christ:

So Mary mild fetched home her child,
And laid him across her knee,
And with a handful of willow twigs,
She gave him slashes three.

Christ then curses the willow:

Ah bitter withy, ah bitter withy,
You have caused me to smart,
And the willow shall be the very first tree,
To perish at the heart.

Above: People still believe trees provide information about the weather—for example, 'ash before oak, in for a soak', which refers to the appearance of the leaves of these trees in spring, predicts a wet summer ahead. Most country people also note the 'blackthorn winter', a spell of cold weather heralded by blackthorn flowers, shown above.

Revenge and religion In many areas, including the Scottish Highlands, leaves of aspen are supposed to tremble continually because the tree provided the wood for Christ's cross. According to Hebridean tradition, the leaves tremble because the aspen refused to bow to Christ as he struggled to Calvary. In Ireland, it was believed that the fragrant bog myrtle was once a tall tree, until it provided wood for the Cross, after which it was diminished to its present low stature.

Individual trees are associated with the activities of early Christian missionaries, of which the Holy Thorn of Glastonbury is probably the best known. St Patrick is reputed to have celebrated mass at the base of a tree which is still growing at Miskaum Glebe in Co Leitrim. A hole in the tree's base contains water which is said to cure warts and other skin ailments. Water said to be useful for treating weak eyes can be found in a cavity in an ancient sycamore tree at Clonenagh on the main Dublin to Limerick road. The tree is said to mark the site of a monastery of St Fintan, and Mass in his honour is celebrated beside the tree.

Healing properties Trees were also believed to provide magical cures. An East Anglian cure for warts was 'Count your warts and then cut off the same number of buds from an elder twig, and bury them.' As the buds rotted, so would the warts disappear. Although most ancient magical cures have been forgotten, cures for warts, usually using elder or hazel, are sometimes still used in rural areas.

One well-known cure for a child with a hernia consisted of passing the child through a split ash sapling, which was then tightly bound up. As the split healed, so would the patient recover. A large number of variations of this cure were recorded in the 19th century and, as the cooperation of an entire community was often required, it seems that it was considered a normal treatment.

In Wiltshire it was believed that neuralgia could be alleviated by taking some of the sufferer's hair, together with cuttings from each of his fingernails and toenails, and placing them in a hole bored in the first ash tree found before sunrise on a Sunday morning. A similar cure for ague, requiring hair and fragments of the patient's fingernails and toenails to be placed in a hole in an aspen, has been noted in Sussex.

The last treatment seems to be a survival of the Doctrine of Signatures, promoted by William Coles in the 17th century. According to Coles, plants and trees exhibited characters, or 'signatures', which suggested the diseases they might heal. Thus the cream-spotted leaves of lungwort showed that the plant might combat tuberculosis, and plants which produced a milky sap might improve the milk production of nursing mothers.

Health and fortune Tree and plant materials were sometimes made into necklaces and worn in the belief that they would either prevent or cure various illnesses. Acorn necklaces were used to cure diarrhoea, and in east London oak apple necklaces were supposed to ease sore throats. A brooch made of hazel nuts was believed to ensure good luck, and it was also believed that an abundance of hazel nuts indicated many births the following spring.

Fair shares for all Such beliefs may reflect the time when the hazel was an important item of food. It was believed that anyone who went nutting on a Sunday would attract the Devil's attention, and in the 1920s a Somerset folklorist, Ruth Tongue, noted a song in which a girl who had gathered nuts on a Sunday bore a baby by the Devil—the child was distinguished by horns and tail. Such ideas may have deterred the unscrupulous from gathering more than their fair share of nuts.

Trees have traditionally supplied us with food and their importance was such that they have been imbued through the centuries with the power to reinforce religious beliefs, to treat ailments, to indicate the weather and sowing times and to predict a harvest or even marriage.

Below: The Fairlop Oak marked the site of the Fairlop Festival established by a certain Mr Day in the 1720s. When this great philanthropist was well advanced in years, the oak lost one of its branches—to Mr Day a sure omen of his impending death. He had the branch made into a coffin and tested it for length.

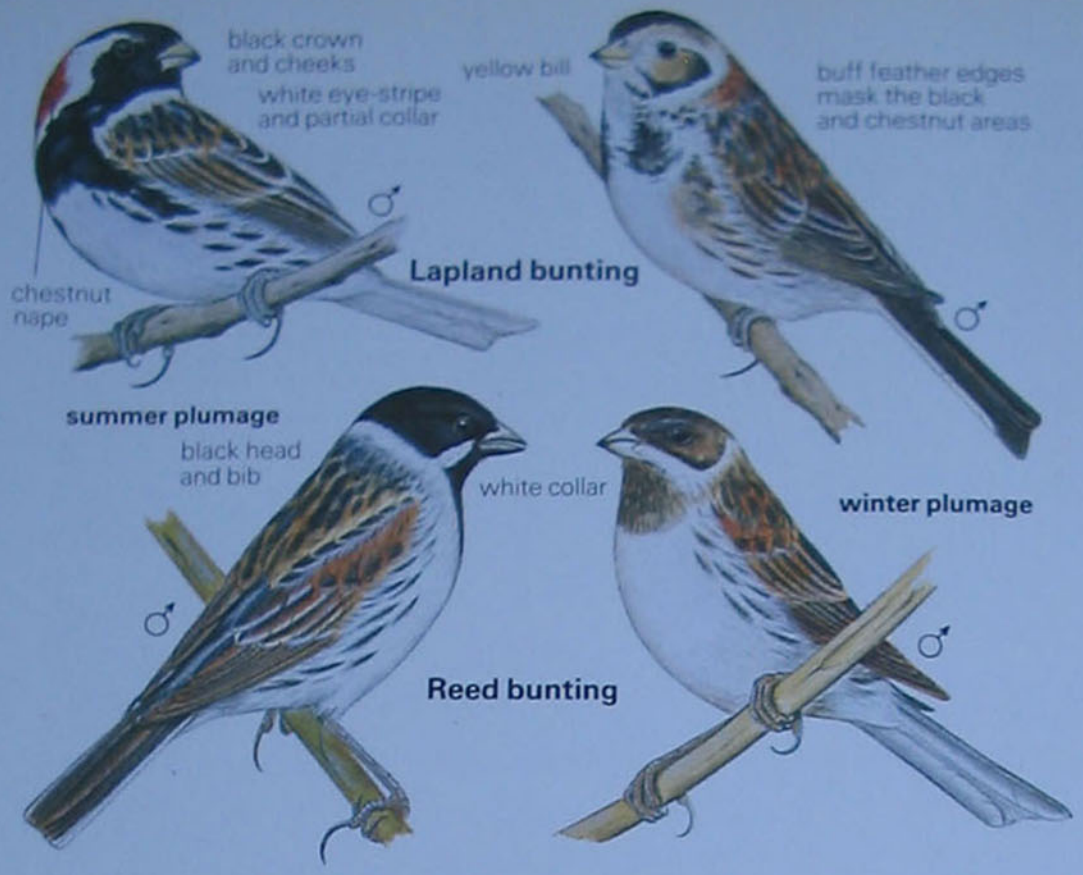
REED AND LAPLAND BUNTINGS

The reed and Lapland buntings are found over much of Europe and northern and eastern Asia. The reed bunting is a well established resident in Britain and Ireland, while the Lapland bunting has only recently begun tentative breeding in Scotland.

Above: A female reed bunting broods the young. The nestlings' diet consists mostly of insects; the young birds leave the nest once they become capable of flight, some 12 days after hatching.

Buntings tend to be unfairly neglected by many birdwatchers. Two superficially similar species are the reed and Lapland buntings. The former is a common resident throughout Britain and Ireland, while the Lapland bunting is a scarce winter visitor and passage migrant to the east coast and, in an exciting new development, a recent colonist in some Scottish hills. Both are sparrow-sized birds, their thick bills signifying their seed-eating habits. In both species the male has a black head in the breeding season which is at least partly concealed in winter and is completely lacking, in all seasons, from the female. In all plumages, both sexes show conspicuous white outer tail feathers.

Reed bunting The reed bunting, the more familiar of the two species, can be found in almost any marshland area in lowland Britain, but is rather scarcer in upland areas. In spring and summer the male sports a pure black head and bib, separated by a white moustachial stripe; and it has a more or less complete white collar round the back of the neck. The underparts are pale, almost white, with some streaking on the flanks. The back and wing coverts have rich dark brown mottling and striping, sometimes almost black. The female is never a striking bird, although she has a pale stripe over the eye and a faint moustachial stripe too.



Reed bunting (*Emberiza schoeniclus*); resident bird of reed-beds and swamps, roaming farmland in winter. Length 15cm (6in).

Lapland bunting (*Calcarius lapponicus*); scarce winter visitor and vagrant in coastal farmland, moors and saltings; a few pairs breed in Scotland. 15cm (6in).

Below: A female Lapland bunting incubating. The clutch of four, five or six pale but reddish-spotted eggs hatch after some 14 days, and the young are fed on the rich variety of insects found in the Arctic summer. They leave the nest within eight to ten days, while still unable to fly.

Nest building The pairs come together on the breeding territory in April and eggs may be found from late in that month through to early July, with two broods (possibly sometimes three) being reared.

The nest is generally sited on or near the ground in a tuft of grass or among a thicket of brambles, reeds or sedges. Some nests have been found up to 3m (10ft) high, but these are exceptional. The female does most if not all of the building, using a variety of grasses to make the rather untidy nest; this is always delicately lined with the finest of grasses, horsehair and occasionally 'pappus' (fluffy hairs) from the seeds of reeds or poplars. The normal clutch is four or five eggs; these show a brown-olive ground colour with dark streaks and spots superimposed.

Local pockets The marshes and reedbeds where they breed are productive areas, and the reed buntings may be thick on the ground. In one location on the overgrown fringes of a series of mature gravel pits, the average territory occupied less than half a hectare (about an acre) of land and emergent vegetation. However, other studies in mixed farmland have shown a density of about one pair per 25 hectares (60 acres), with large areas completely devoid of the species and small pockets, coinciding with ideally suitable habitat, of much denser populations. Over the last 20 years or more the reed bunting, in Britain, has steadily colonized new areas and can now be found in a much wider variety of habitats than formerly. Pairs now breed in tangled vegetation in totally dry habitats – for example chalkland scrub and even in the middle of cereal growing districts, nesting in the crops where an adjacent hedge or fence gives the males the possibility of songposts for territorial advertisement.

Moving in flocks Although the reed buntings are with us throughout the year, there is quite a lot of local movement at different times of the year. After the breeding season, fairly large flocks of locally bred young birds may be formed, exploiting abundant autumn food supplies of freshly matured seeds. Later, in October and November, after some of these food resources have been used up, the birds tend to move from site to site and reed buntings may be found flocking with finches and other buntings along hedgerows or in flocks feeding in fields. Often the reed buntings continue to roost in reedbeds, preferably over water so that they have additional protection from predators. One characteristic is that when the weather becomes particularly severe they are often found visiting gardens and seeking food at bird feeding stations. However, once the weather improves, they are no longer seen in these places.

Bird ringing has shown that during the winter and early spring the population of reed buntings in a given locality may be very transient: roosts that have room for 100 birds at most on any one evening may be used by 300 individuals passing through during the course of six or eight weeks. Often the females form the majority among these roving birds, for the males do not move so far; it seems likely that they remain in the vicinity of the breeding territories in order to be able to reclaim them as soon as the weather becomes warmer in spring.

Arctic replacement The reed bunting is, in world terms, a very widespread bird. Our populations in Britain and Ireland are on the species' western flank, and the same species can be found over almost all of the rest of Europe and across Asia to northern Japan and Kamchatka in the USSR. In some areas the birds are highly migratory – as, for example, in Arctic Scandinavia – and some birds from Norway reach the east coast of Britain during the winter. This is a feature the species has in common with the much rarer Lapland bunting. This species is very much a high Arctic replacement for the reed bunting and

during the breeding season it is found all round the North Pole with populations in Greenland and over the whole of Arctic Canada to Alaska.

The male Lapland bunting looks similar to the male reed bunting but has a striking chestnut nape. One of the easiest ways to identify it is from the cheerful 'turrit' or 'tick, tick, tiew' calls, which are reminiscent of the calls of skylarks or even turnstones. They are most often seen in small flocks on coastal marshland, and may even be found in the company of snow buntings.

Nesting in tundra In spring the Lapland buntings migrate to the open tundra of northern Europe, where the males begin to sing and display. The tundra seldom has suitable song posts and so, unlike reed buntings, they utter their song in circling flight after the manner of the skylark.

Since the Arctic summer is so short, only a single brood can be raised and all populations are migratory, for the breeding areas would be untenable during the winter. Apart from those that reach Britain, other birds may be found in the Netherlands and north Germany and across southern Europe and Russia to the coasts of the China Sea. The autumn passage starts in September, but it seems that many of the migrants wintering in Britain start their return to the breeding grounds quite early in spring. By the middle of March, many of their traditional haunts are devoid of the species.

The Scottish pairs The recent records of breeding in Scotland have been most exciting. In 1974 a pair was found and may have bred; but proof, in the form of a male with two females and two successful nests, came in 1977. Besides this proven case, up to 14 other pairs of Lapland buntings at five other sites may have bred. During the next two years up to five sites were occupied, and 13 pairs were proved to have bred. More records of polygynous males (with more than one mate) were reported, including one considered to have four females. Unhappily the situation in 1980 was not so good, with only a single pair at a single site listed in the national report on rare breeding birds.

Climatic change This new colonization was not a total surprise, for a wide range of northern species have colonized northern Britain in recent years as a result of longterm climatic trends. The best examples are the goldeneye, sanderling and purple sandpiper; a particularly spectacular but less successful example is the snowy owl, which bred here for nine years from 1967-75 but not since then.

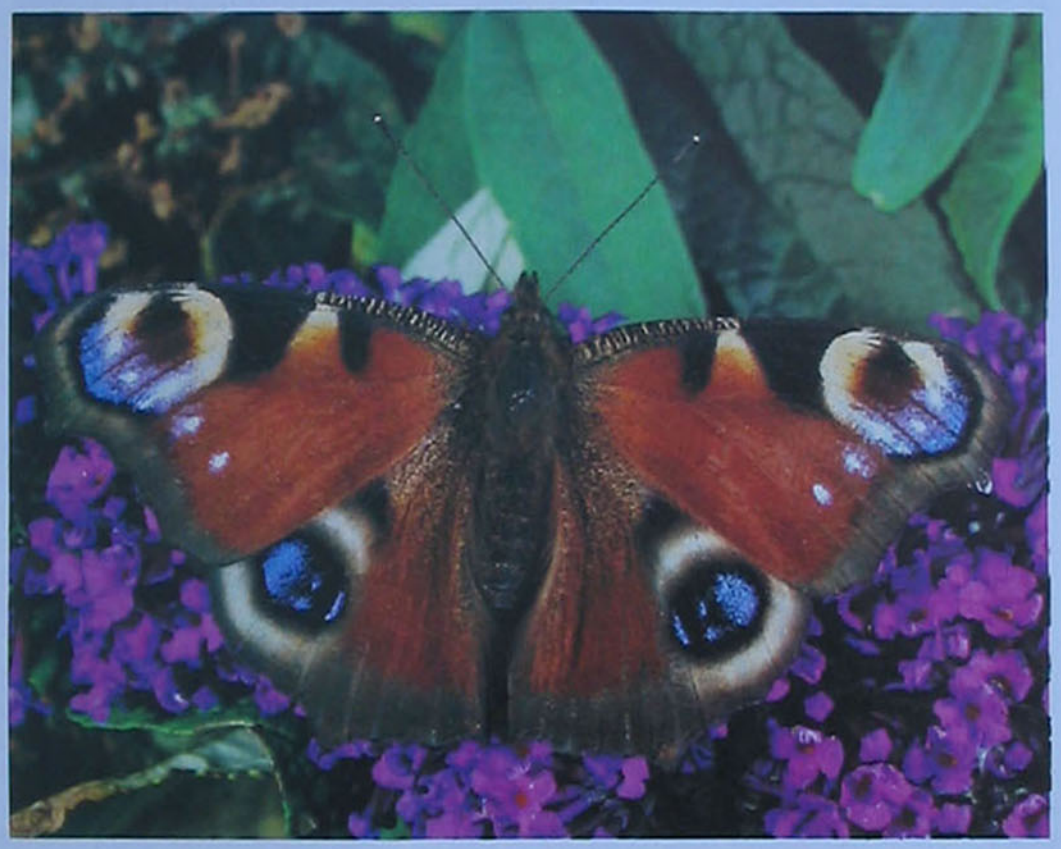
Apart from the snowy owl, these northern colonizers are not particularly eye-catching, and their breeding attempts have not, in most cases, been disturbed by birdwatchers or anyone else.

Above: The male reed bunting's song is rather monotonous: although males vary in the choice of phrase they sing, each tends to repeat his one phrase interminably. One of the most usual consists of three single phrases and a terminal flourish: 'tsik, tsik, tsik, tsissisik'. The singing bird defends quite a small territory and is very conservative in his choice of song-posts. These may, in the middle of a marsh, be no more than prominent tussocks of grass, but elsewhere posts, bushes or trees may be used. He returns regularly to each of his posts, and local birdwatchers can easily learn exactly where to find him.

Right: A male Lapland bunting brings food to his chicks. This nest is situated in moorland vegetation that is typical of the Arctic tundra, as well as the mountainous habitat of the few Scottish breeding pairs. The male looks quite like the male reed bunting, but has a striking chestnut nape to his neck and is darker on the breast and flanks. He lacks the reed bunting's moustachial stripe, but has a pale buff stripe from the nape to above the eye. The female has a residual partial chestnut patch on the nape of the neck, though this is not easy to see. Juveniles, like the one being fed here, have lighter plumage and a light stripe across the crown from front to back.

HOW INSECTS FIND THEIR MATES

Insect communication between members of the same species is directed principally towards sex. Before mating, partners must locate and recognise one another–not a simple matter since they can be separated by distances as great as two miles.



Above: Peacock butterflies, in common with some other large day-flying insects, have developed bright, distinctive colouring on their upper wing surfaces which enable partners of the same species to recognise one another prior to mating.

Most insects live solitary lives, widely dispersed in a mixed habitat which is usually shared with other similar species. In order to reproduce, the prospective partners–male and female–first have to find and recognise each other. This is done by using either one or a combination of the senses–sight, sound or smell.

The allure of scent The sense most frequently involved is scent, normally emitted by the more passive female and detected by the active male. The scent, known as a pheromone, is chemically unique for each species so the male does not waste time pursuing females of another species. After mating the female usually ceases to secrete the pheromone.

The sex pheromones of moths have been closely studied, and field experiments show that males flying upwind can find females at remarkable distances. Two miles and more have been reported in tests using marked males released at increasing distances from the 'calling' female. The pheromones are produced in minute quantities–at such large distances they must be diluted to extremely small concentrations. Tests on the gypsy moth have revealed that the male responds to just one tenth of a thousand of a millionth of a gram of pheromone.

Colour identification The sense of smell probably works in a similar way in a great many other insects, but some of the larger day-flying species use their eyes to locate and recognise partners.

Butterflies are the most obvious example, their bright colours having developed for recognition during the course of evolution. They are usually displayed on the upper wing surface; by closing their wings over the back butterflies can change their appearance from vivid conspicuousness to that of withered leaves or pieces of bark.

The males of many butterflies establish a territory and wait, resting on a leaf or the ground for females of their own species to fly past. When one arrives the male flies up to intercept and tries to persuade her to descend on to his perch. If an intruding male of the same species appears the first male flies up and drives it away; some males intercept any butterfly which appears regardless of the species. Before mating, final recognition is established by perception of a pheromone.

Dragonflies use their sight to control almost all their activities. The males are strongly territorial and fights between rivals frequently result in torn wings and amputated legs. The females roam more widely than their partners. When a female enters a male's territory–which is usually on or near water–the male flies up to her and attempts to mate. She normally accepts him if she has not mated already.

Night-lights Nocturnal insects can communicate visually only if they are luminous. In Britain the one common species to fall into this category is the glow-worm (*Lampyris noctiluca*)–a beetle. The female reaches maturity when she still resembles the form of a larva, and rests among the grass at night, displaying the brightly luminous organ that is situated on the underside of her abdomen. The male, a fully developed beetle, but only slightly luminous, flies about and is guided to the female by her bright greenish-yellow light.

Pest control

In America, where gypsy moths have become tree-pests, experiments are being undertaken to see if their pheromones can be used for pest control –a glass rod dipped in a solution of female pheromones is placed near the male's antennae. His response to the test indicates that scent organs can detect only female pheromones of the same species.

Scent organs

The female emperor moth (near right) emits pheromones from scent organs which are situated at the rear of her abdomen. These pheromones may be detected from as far away as 3km (2 miles) by the male (far right), whose elaborately feathered antennae are designed to increase the area available to detect mere molecules of pheromone.

Left: Communication between male and female grasshoppers is vocal—the male doing most of the 'talking'. He has two distinct songs. One is loud, calling the female to his side but also challenging other male grasshoppers to keep their distance, while the second occurs when the two partners are together. This is a quiet gentle chirping, conveying a message quite distinct from that of the normal loud song. Female grasshoppers are also capable of singing, normally in reply to the male's call, but theirs is a quiet, subdued song. Both sexes create these sounds by rubbing their hind legs (which carry a row of stridulating pegs) against the forewings.

There are no 'fire-flies' in Britain, but in some countries where they are abundant, different species are distinguished by differing codes of flashes and flight patterns that enable each insect to find its appropriate partner.

Insect song Communication by sound is common among the Orthoptera—grasshoppers, crickets and bush-crickets. All produce their songs by stridulation, a sound which can be imitated by stroking your finger-nail along a comb.

Grasshoppers have a row of minute, evenly spaced pegs on the inner side of the femur of each hind leg which they stroke against prominent veins on their forewings. Each species has a characteristic arrangement and number of pegs which produce a unique song that can be distinguished by other grasshopper species, and by the human ear. The singing is done mostly by the males and serves to attract the females, who reply to his call, despite having weaker stridulating pegs. Grasshoppers' hearing organs are situated on each side of the base of the abdomen.

Crickets and bush-crickets stridulate in a completely different way. Their forewings overlap on to the back, one bearing a ridge, and the other a row of pegs or teeth; sound is produced by rapidly moving the wings, and is again distinct for each species. Curiously, in crickets the right wing overlaps the left, and in bush-crickets the left overlaps the right. Both these groups of Orthoptera differ from grasshoppers in having their hearing organs on the tibia—the fourth segment of their forelegs. Females and males both possess these hearing organs, although only the latter stridulate.

The other vocal group of insects is the cicadas—members of the 'bug' order, Hemiptera. One species only, *Cicadetta montana*, occurs in the British Isles, and is restricted to Hampshire. Only the males have a song which again serves to attract the females and is created by the vibration of a stretched membrane at the base of the abdomen.

In warmer countries, where cicadas are more common, their songs are a familiar sound at dusk and can be extraordinarily loud.

Courtship rituals

In some insects, when an encounter has been brought about by location and recognition the male has to perform a courtship display before the female will accept him as a sexual partner. This is the case with many butterflies—the casual observer can often spot them performing in this distinctive manner. The courtship ritual of the grayling butterfly, in particular, has been closely examined. The female initially emits a pheromone which the male detects with his highly sensitive antennae, helping him to confirm visual identification—the distinctive colouring on her forewings. Having established that the female is the same species, he flies up and intercepts her flight. If she is ready to mate she alights on the ground with the male, taking up a position facing him. The male then proceeds to open and close his wings several times, eventually clasping the female's antennae between them. In this way he transfers scented scales—androconia—from his wings to her scent organs (the olfactory receptors), thus stimulating her to proceed with mating. This scent is an aphrodisiac and quite distinct from the pheromone by means of which recognition was originally established.

MAMMALS OF WETLAND HABITATS

The wetlands and inland waterways of Britain provide an abundance of food and shelter that has been exploited by many species of mammals.

The wetlands and inland waterways of Britain are rich in plant and animal life. Freshwater habitats, whether fast-moving rivers, man-made canals and reservoirs, or the marshy edges of lakes and ponds, provide a source of food and shelter that has been exploited by many of our mammals.

Only three native mammals of inland Britain are truly aquatic: the otter, the water vole and the water shrew. They spend most of their lives in and around water and usually build homes in a waterside bank. However, more essentially land-living native mammals also live in close association with water for parts of the year, seeking food and refuge in fertile areas around the wetlands. Two introduced mammals, the coypu and the mink, are also firmly established in freshwater habitats.

Freshwater habitats The wetlands and inland waterways can be divided into two main types: flowing water (rivers, canals and streams), and still water (lakes, ponds, marshes and fens). Water circulates in the atmosphere in the form of rain, and arrives in these habitats as a result of drainage from surrounding land, carrying with it dissolved nutrients that make it a medium suitable for plants, and hence animals, to colonize. The composition of wildlife is determined by such factors as the flow rate of the water, its temperature, chemicals and nutrients.

High in the mountains the water flows too fast for flowering plants to take root. Algae, mosses and liverworts mainly grow underwater and the most common animals here are insect larvae. Further downstream becks and deep pools harbour many species of fishes. Reed beds line the margins of slower lowland stretches of river and streams, and here many small aquatic mammals, such as water voles and water shrews, make their homes. Larger mammals are frequent visitors.

In lakes most animal life flourishes in the shallows where sunlight penetrates to the bottom enabling rooted plants to grow and provide oxygen. Lakes and ponds are relatively independent worlds with their own constantly changing balance of plants and animals. Their edges and shores provide homes for water voles and shrews, and for many plant-eating mammals and the carnivores, especially weasels and stoats, that prey upon them. In summer the insect life of old-established ponds and wooded lakes attracts bats during the early evening.

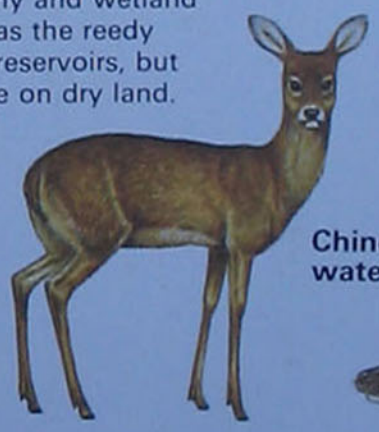
Marshes and fens are waterlogged areas overgrown with reeds and other plants that flourish in patches of standing water. Marshes, often sited at the edge of a pond or lake, provide shelter for voles, mice and shrews, while coypu and otter live in fens which have deep-sided channels and flooded dykes. Canals – man-made habitats – are often supplemented by large reservoirs, and have most of the characteristics of shallow ponds and lakes because the flow of water into them is slow and usually only just sufficient to

Above: None of our essentially terrestrial mammals has taken to water quite so well as the brown rat. From areas of dense ground cover it enters the water regularly and is often mistaken for a water vole. It tends to keep to the surface, however, whereas the vole dives if disturbed. The vole can also be identified by its short tail.

Opposite page: The coypu can cause extensive damage to crops, and to reedbeds and marsh flora.

Some wetland mammals

Below: Chinese water deer prefer marshy and wetland areas such as the reedy margins of reservoirs, but can also live on dry land.



Chinese water deer

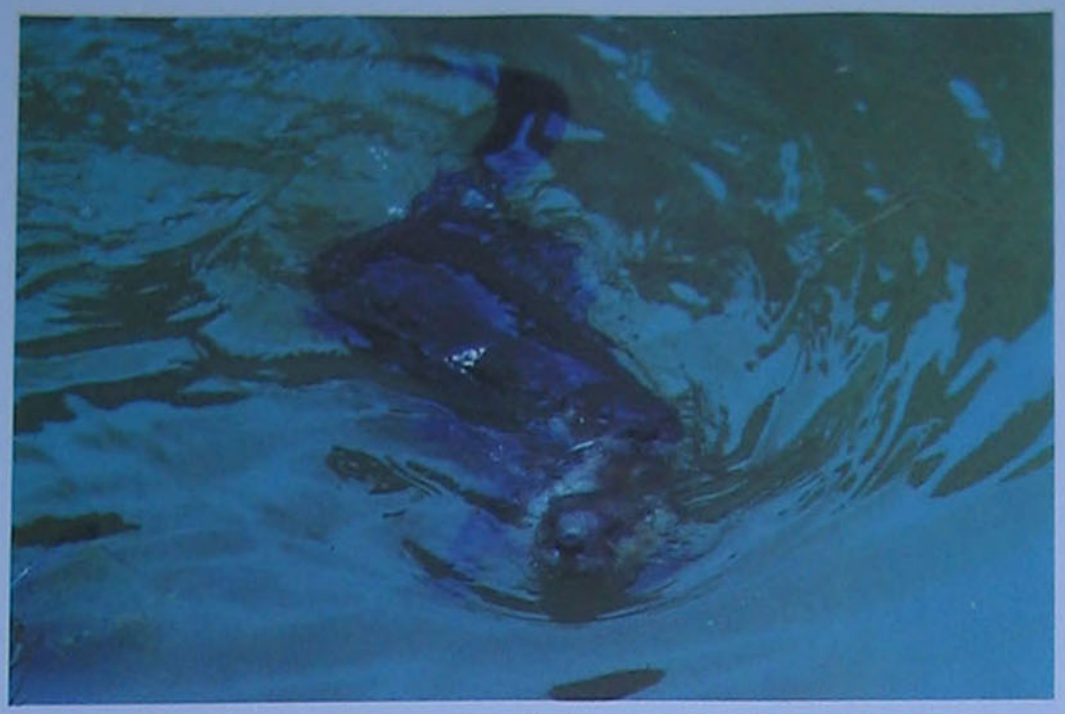
Below: The American mink has established itself in most counties in inland wetland areas. It is a threat to many species of wildlife.

Mink

Other mammals can swim too

Hedgehog

Left: Most mammals can swim if they have to, and the hedgehog is no exception. It often swims in garden ponds, but moves to dry land when possible.



Above: Although the otter is a land mammal, it spends a great deal of its life in water, especially at dusk and during the night when it is feeding. It relies on its good eyesight and sensitive whiskers to detect the movements of passing fishes. It makes numerous short, sharp dives, and eats small fishes in water. Larger prey is taken to the shore. Here two otters are mating. The young are born on land and they learn to swim at about three months old.

maintain the water level.

Waterside dwellers Our most easily seen aquatic mammal is the water vole (often incorrectly called the water rat). Patches of bank where the plants have been bitten off and piles of chopped grasses and reeds on small rocks or patches of mud at the water's edge are all good indications that water voles are present. Unlike land-living voles, they catch and eat many animals such as snails, worms, fish and spawn. Water voles live in complex burrow systems in the banks of canals, lakes, slow-moving rivers and marshes, with entrances above and below water level.

The otter is much more difficult to see. Not only is it much rarer than it was, but it is shy and secretive, lying up in burrows, drains, root cavities and reed beds during the day, and preferring stretches of river with good ground cover on the banks. It hunts over enormous distances both in water and overland.

The water shrew is the smallest of our water-living mammals. Although it is only a fraction of the size of the otter, it is just as ferocious and determined a hunter. Like all shrews, it needs enormous amounts of food to maintain its high metabolic rate and it eats its own body weight of living prey every 24 hours. It lives in a variety of watery habitats but is also found in woodland up to 3km (2 miles) away from water.

Waterside visitors The rushes, shrubs, grasses and trees of the fertile areas around wetlands and waterways have been described as 'biological crossroads' where land-dwelling animals mix with those that spend most of their lives in water. Small mammals such as short-tailed voles, mice and shrews are attracted to the rich plant and insect life, and they in turn attract predators such as foxes and badgers–their tracks are often quite clear in the mud. Deer also feed on the vegetation.

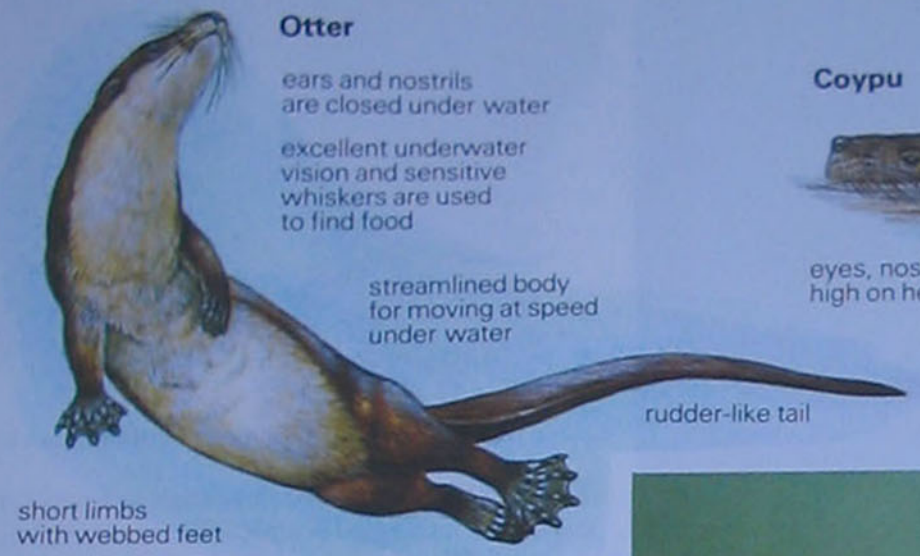
During the warmer months of the year the insect life above slow moving and still water attracts the Daubenton's bat, sometimes called the water bat. It can occasionally be seen at dusk, flying low and taking aquatic insects on the wing. Prey is eaten in flight. Our most common bat, the pipistrelle, also hunts over water, usually near old deciduous woodland. It takes prey in a similar manner to the Daubenton's bat, but does not keep so constantly close to the surface of the water.

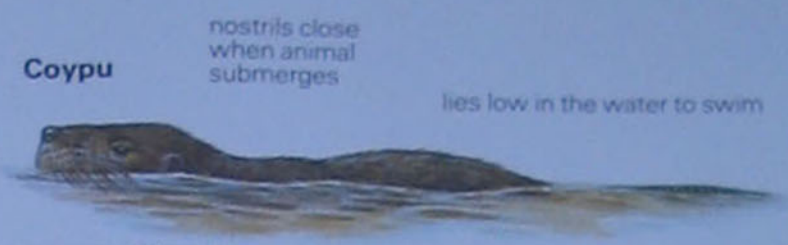
Moles and polecats, two mammals that one would not necessarily associate with water, are in fact quite at home in damp areas. Even a pine marten has been known to live in a riverbank burrow, very far from its normal habitat.

Introduced mammals During the early part of this century three introduced mammals

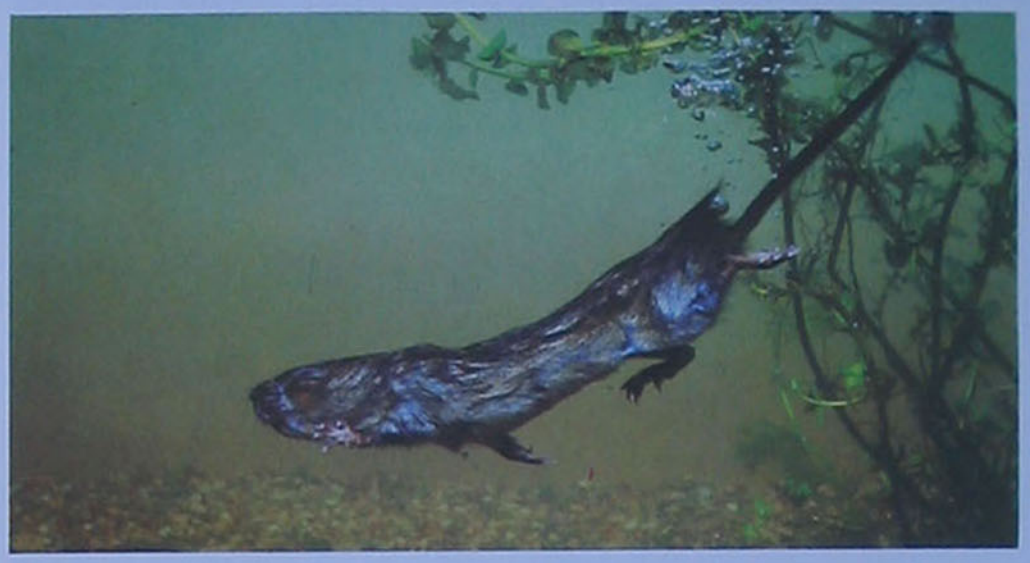
Left: The Chinese water deer was introduced to Woburn Abbey in 1900. It stands about 50cm (20in) high and can be recognised by the long upper canine teeth which protrude from the jaw, especially in the male. In its native China and Korea the deer inhabits swampy country, reedbeds and grassland. In Britain it is found in open grassland and woodland in parts of Bedfordshire, Buckinghamshire and Hertfordshire, especially in wetland areas. It has bred successfully in the fenland areas of Norfolk and Cambridgeshire. Look out for the distinctive tracks and areas of flattened reed where the deer have been lying up during the day.

Adaptations for life under water





Below: The water vole swims and dives, although its body is not as well adapted for water life as that of other mammals.



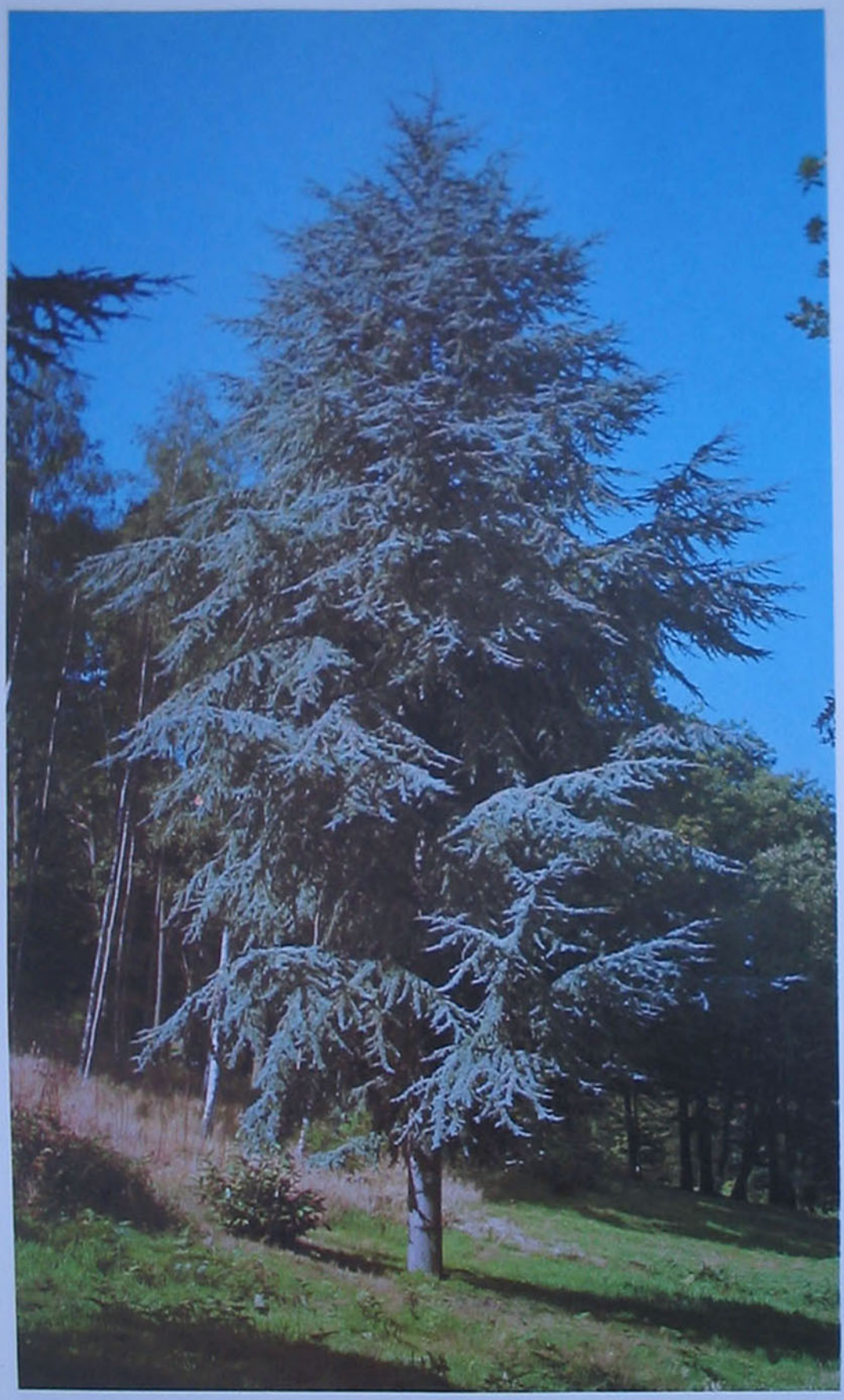
that live near wetlands in their native countries began to escape from captivity and form feral communities. These were the Chinese water deer, the American mink and the coypu. The Chinese water deer is a grazer rather than a browser and causes little damage to vegetation, but the other two species have had a great effect on the ecology of British wetlands. They were originally introduced for fur production. Some species of waterfowl have now vanished from mink-infested areas, and where mink are hunting water voles desert their burrows for higher ground. The coypu, a vegetarian, has damaged crops, especially sugar-beet.

Little competition exists overall between the various mammal species. Our native aquatic mammals co-exist well, and the presence of such predators as weasels and stoats ensures that the numbers of rodents and small mammals in the surrounding areas are kept in check. However, the introduction of alien species has upset this balance. The mink occupies a feeding niche not previously occupied by our native carnivores because it is both aquatic and terrestrial. In addition to harming waterfowl, it is now thought to be partly responsible for the decline of the otter, because it competes for the same food.

Changed habitats Natural changes, such as sudden torrential rain, can endanger mammals. The mole, for example, has to evacuate its burrow if it becomes flooded and swim for safety to higher ground. Smaller mammals may be drowned or chilled if their fur becomes waterlogged.

Man has the greatest effect on our wetland mammals. The drainage of land, the increasing use of waterways for recreation, disturbance by Water Authorities, pollution, and hunting have all contributed to the decline of the otter, to give the most dramatic example. And pollution from whatever source makes the water uninhabitable and is a direct threat to mammal populations everywhere.

Below: The mole finds the damp marginal land around fens ideal for burrowing and a rich source of earthworm and insect prey, although it tends to avoid marshy and heavily waterlogged ground. The mole is an excellent swimmer and its front feet are equally well adapted for swimming and for digging.



Common silver fir Caucasian fir

SILVER FIRS IN BRITAIN'S PARKS

The silver firs – so called for the two narrow bands of white on the underside of the leaves – number just four species in Europe. Although none grows wild in Britain, all four have thrived in our parks and forests since their introduction many years ago.

There are about 40 species of silver firs worldwide in Europe, North Africa, temperate Asia and the Americas. Although none of the four European species grows wild in the British Isles, they are commonly grown in the valleys of western Scotland. They thrive in a cool wet climate provided there are no late spring frosts.

The silver firs belong to the genus *Abies*. They can be distinguished from other conifers by the combination of erect cones, which break up on the tree, and single needle leaves which, on falling, break off from a circular disc-like base on the branchlet. The closely related spruces, of the genus *Picea*, are perhaps the most similar, but their cones are pendulous and the bases of the leaves are attached to the twigs via small hard pegs, which stick out when the leaves have been shed.

Both spruces and firs are typical conifers. They are conical in shape, often narrowly so, and regular. Growth is symmetrical, the trees developing a single main shoot with horizontal tiers of branches.

The common silver fir The most familiar species in Britain is the common or European silver fir. It comes from the mountains of central and southern Europe, where it is a characteristic and dominant tree forming large forests. It is especially common in the Alps, the Tatra Mountains of Czechoslovakia and the Balkan Mountains. To the west it reaches the Pyrenees and the adjacent Montseny Mountains of northern Spain. Eastwards it stretches to the Bialowieza forest in eastern Poland, the best example of a large natural forest in Europe.

In Britain the tree grows to nearly 46m (150ft), with a pyramidal crown and stout trunk. When young the trees are conical with regular whorls of branches. The side branches tend to be horizontal, curving up slightly at the tip. As the tree grows, the lower branches become shaded, so that they die back and fall off cleanly at the trunk, leaving a smooth, straight bole.

The leaves tend to occur in rows on either side of the shoots, spreading around the shoot in layers, except at the top of the shoot where

Grecian fir Spanish fir

they leave a broad V-shaped gap. They are needle-like and of varying lengths, the longest being about 3cm (1in) long. The leaves are dark green on top, with two narrow white bands on the underside. This is the origin of the name silver fir. The cones are brownish-green when young, changing to brown as they mature, when the spine-like bracts become protruding and reflexed.

Survival The common silver fir has been cultivated in Britain since 1603 and the tallest tree measured in Britain, in Argyllshire, was probably planted in 1680. The species does not grow well in south-east England, preferring the moist but frost-free areas in the west. It survives well in shade and was much used in forestry for planting under other species. It has, however, proved susceptible to heavy attack by a minute aphid, and this has limited its use in forestry. The trees develop gouty swellings on the branches, and clusters of woolly hair which spread to both trunk and branches. In England the common silver fir is usually seen in parks and arboreta, but on the Continent it is widely planted as a forest tree.

The endangered Sicilian fir The closest relative of the common silver fir is the Sicilian fir which, in contrast to the common silver fir, is an endangered species. Today it only grows in one remote valley in northern Sicily, but had earlier formed extensive forests on the island. These were felled, and at one time only 20 immature trees remained, but the tree is now being planted once again. Its height remains unknown–it is estimated to reach over 15m (50ft), but as only a few young trees have survived, it could reach much higher.

The rare Spanish fir Although rare, the Spanish fir is not in danger of extinction. It is occasionally planted in British gardens, but in the wild grows in the Ronda mountains in southern Spain, possibly also occurring in the mountains of Morocco. It grows on north-facing limestone slopes in a part of Spain that is especially noted for the richness and exuberance of its spring flora.

The Spanish fir is sometimes known as the hedgehog fir because old trees consist of dense masses of shoots, much of them dead, and numerous twigs.

The Greek fir Common in the Greek mountains, the Greek fir reaches at least 36m (120ft). Like the Spanish fir, the Greek fir will grow in the drier eastern areas of England and is sometimes seen in gardens. It is distinguished from other silver firs by sharp-tipped leaves which stand out around the shoot, its prominent spines below the cone scales and the presence of resinous buds.

The Caucasian silver fir Originating from eastern Europe, this species was discovered in 1836 and introduced into Britain a few years later. It is one of the handsomest of the firs but, like the common silver fir and other fir species, it can be attacked and even killed by aphids.

Above: Maturing cones of the common silver fir. The leaves on the cone-bearing branches are pointed and stiffer than those on other branches, and they curve upwards.

Above left: Four species of silver fir, showing their different cones, needles and habit of growth.
Common silver fir (*Abies alba*). Native to the mountains of central and southern Europe. Introduced here in 1603. Height to 46m (150ft).
Caucasian fir (*Abies nordmanniana*). Native to the Caucasus and parts of Turkey. Introduced in 1848. Height to 40m (130ft), shown here with immature cone.
Greek or **Grecian fir** (*Abies cephalonica*). Native to Greece. Introduced in 1824. Height to 36m (120ft).
Spanish fir (*Abies pinsapo*). Native to southern Spain, Morocco. Introduced 1839. Height to 33m (110ft).

Opposite page: The common silver fir is the most widespread of the European species in Britain; it grows particularly well in the west of Scotland.

Left: Considered by some to be the handsomest of the silver firs, the Caucasian fir (shown at the front here), can grow to more than 60m (200ft) high in the wild.

PARASITIC FLOWERING PLANTS

That fungi live parasitically on other plants, or on decaying vegetation, is familiar to many people, but this same life-style is also adopted by some flowering plants that are distinctive for their complete lack of green colouring.

Most flowering plants obtain their food by photosynthesis, a process whereby the energy of sunlight is converted by the green pigment chlorophyll into sugars for growth and reproduction. It is chlorophyll that gives stems and leaves their green colour.

However, some flowering plants lack the chlorophyll necessary for this task. Instead, they obtain their energy in the same way that fungi (which are non-flowering) do: they feed on organic matter that has already been created by green plants. Some flowering plants in this category are parasitic and feed on living plants; others are saprophytic and feed on dead and decaying organic matter. Since they lack chlorophyll, these plants are not green but range from a ghostly white to reddish-purple.

For centuries these plants have fascinated naturalists. Indeed, for a long time it was thought that they might not be flowering plants at all but strange freaks of nature that spontaneously emerged from other plants, a belief no doubt encouraged by their often eerie colouring and appearance.

Plants attacked by a parasite always suffer to some degree, though it is in the parasite's interest not to weaken the host too much in case the latter should die. If this happens, only a few parasites are capable of surviving by continuing to feed on the tissues of the dead plant. Most parasites, however, cannot switch to a saprophytic way of life, and therefore die with their hosts.

Clinging dodder A major flowering parasite is dodder, belonging to the bindweed family, Convolvulaceae. Britain has two native species: the common dodder and the large or great dodder. The latter usually grows only on stinging nettles and hops, while the more widespread common dodder is found on gorse, heather and various other plants.

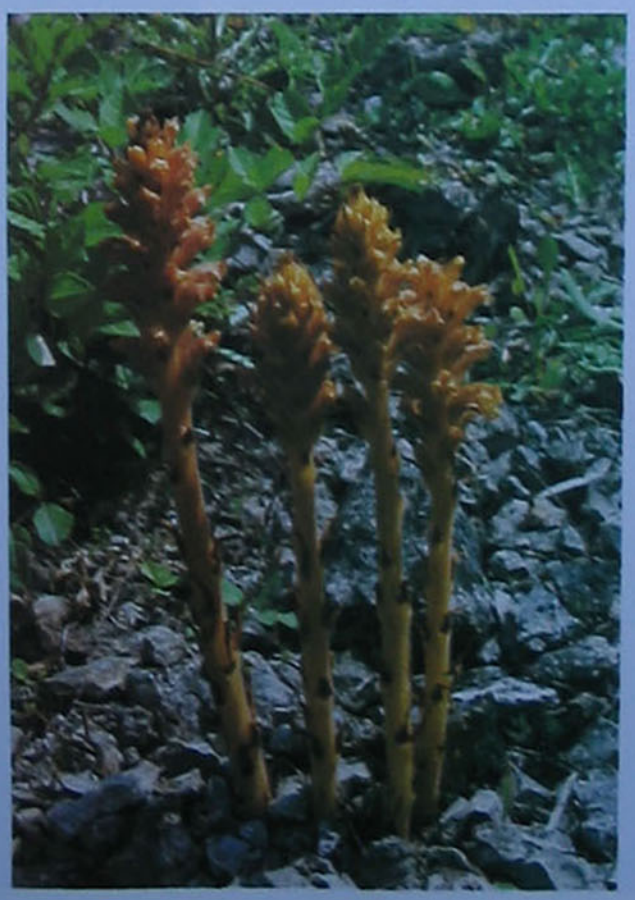
Above: The reddish thread-like stems of common dodder (*Cuscuta epithymum*) entwined around gorse. This is a fairly common plant in southern England but rare in the rest of the British Isles. The less common greater dodder (*C. europaea*) has larger flower heads (about 10-15mm/½in across, those of the common dodder being about 5-10mm/⅓in across). It also parasitises different plants, usually stinging nettles or hops.

Like other members of the bindweed family, dodders are climbing plants, their reddish thread-like stems closely twining around those of the host plant. Minute reddish leaves, resembling scales, are borne on the stems. From July to September small pinkish-white flowers are produced in tightly packed, rounded heads.

Dodder begins life as a germinating seedling. This produces a short shoot which grows downwards, while above ground a curving shoot begins to twine around the first plant with which it comes into contact. If this plant is a suitable host the dodder seedling will thrive, sending out small suckers to penetrate the host's stem and extract nourishment.

In different parts of the country the dodders are known by various different names, for example, hellweed and devil's guts. Both names reflect the farmer's dislike of this twining menace to his crops, for controlling this weed is not easy. One method is to remove all suitable hosts from an area where dodder, or any other parasite, is known to occur. Another method is to check crop seeds carefully before sowing to make sure that dodder is not being introduced to a new area, or even to a new country in the case of crop seeds being exported. At the beginning of this century, crop seeds examined on behalf of the Royal Agricultural Society were found to contain as much as 6% dodder seed in some cases. However, modern seed hygiene helps to keep parasite numbers down.

Left: Common dodder growing on gorse near the Cornish coast. This species grows on a much wider range of host plants than the greater dodder, including heathers and such members of the pea family as gorse.



Right: Many parasitic plants can grow only on a few host species, since their food requirements are so precise. For example, the tall broomrape (*Orobanche elatior*) is confined to chalky soils, the home of its only host, the greater knapweed. The tall broomrape is common only in parts of southern and central England. It flowers in June and July, reaching a height of 65cm (26in). The brown scaly structures attached to the stems are reduced leaves.

Root parasites The dodders are exceptional among British plants in being stem parasites. Most parasitic plants in this country live on roots, an example being toothwort. The pale stems of this plant can be found growing in woods and hedgerows on the roots of such trees as hazel and elm, to which they attach

Above: A flower head of greater broomrape (*Orobanche rapum-genistae*). The thin brown-tipped filaments are calyxes of the individual flowers. Inside each flower there is a pair of stigmas. All broomrapes have two stigmas per flower but only on a few species, including greater broomrape, are they borne separately. Usually, they are fused together at the top of the style.

themselves by means of small suckers similar to those of the dodder.

In spring, cream or pale pink flowering shoots arise from branching creeping stems covered with small whitish scales. These scales are actually modified leaves. (This reduction in leaf size is characteristic of parasitic flowering plants. In green plants the leaves are the most important region for the manufacture of food by photosynthesis, a role that is redundant for the leaves of a parasitic plant, by their very nature.)

Toothwort seeds do not germinate until they have come into contact with the roots of a suitable host after being washed down through the soil by rain, no matter how favourable other conditions might be for germination. It is thought that germination is stimulated by a chemical substance released from the roots of the host plant.

Parasite broomrapes Parasitism has evolved independently in several different plant families. In some families it is rare, but the family to which toothwort belongs, the broomrape family (Orobanchaceae), is notable for being entirely parasitic.

There are many different species of broomrape to be found in Britain. Among the commonest are the greater broomrape which is found on the roots of broom and gorse, the lesser broomrape, which lives mainly on clover, and the tall broomrape, which is confined to chalky soils where the greater knapweed grows. All these examples show how particular many parasitic plants are in their food requirements, so that only a few species – sometimes just one – can be utilised as a host.

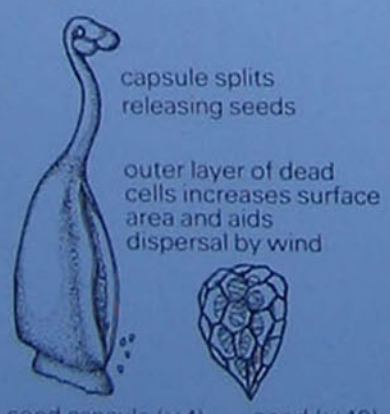
The difficulty in finding a suitable host is one of the limitations of parasitism. If the roots of the seedling parasite do not come into contact with an acceptable host soon after germination, the seedling will not survive.

One way in which parasites overcome this problem is by producing vast numbers of seeds to increase the chances of some of them eventually encountering a suitable host. The seeds of all broomrapes are extremely small and, when shaken from their capsule by the wind, may be carried considerable distances. It has been calculated that a single specimen of lesser broomrape can produce a staggering 100,000 seeds in a year, each weighing no more than 5mg (ie, about 5000 seeds to an ounce).

Saprophytic plants Two of the most common saprophytic plants in Britain are the bird's nest orchid and the yellow bird's nest (not an orchid). Both species need large amounts of humus to supply them with food and so are usually found growing in woods where substantial amounts of rotting leaves have accumulated over the years on the woodland floor. Because they do not need to photosynthesise the lack of sunlight in such a situation does not affect them and they can grow in very shaded areas where few

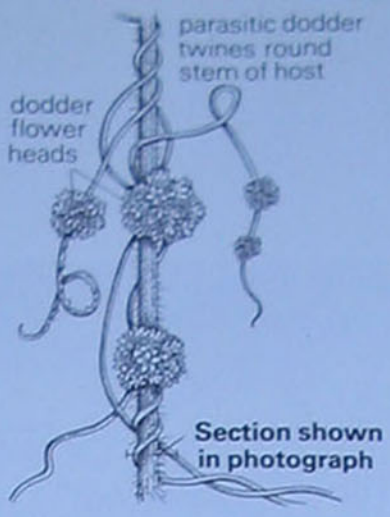
Below: Greater broomrape parasitising broom, one of only two plants that it can grow upon, the other being gorse. The association of greater broomrape and broom accounts for the common name 'broomrape' and also for the former's specific name *rapum-genistae*.

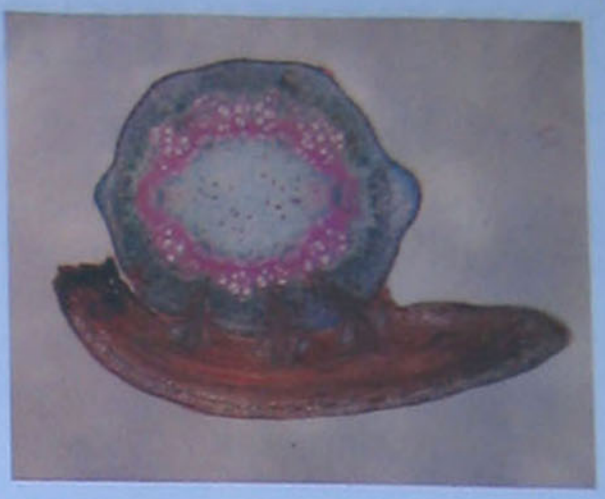
Below: Being so selective in their hosts, broomrapes compensate by producing huge numbers of seeds to increase the chances of one germinating near an appropriate plant. For example, it has been calculated that a single seed capsule of lesser broomrape contains about 3000-4000 seeds.



Stem-feeding dodder

The great dodder is usually found growing on either stinging nettles (as here, near right) or on hops. The young seedling sends up a shoot that entwines around the host plant. Then a small disc grows from the parasite stem and attaches itself to the surface of the host stem by fine, hair-like growths. From the disc, a root-like structure grows out and penetrates the host stem to connect the parasite with the host's conducting and storage tissues (far right). Once the dodder is established its root dies and, from then on, it is completely dependent on its host for all its needs.





Left: A pale pink flowering shoot of toothwort (*Lathraea squamaria*). This species parasitises the roots of such trees as elm and hazel, and can be found in woodland and hedgerows. It flowers in April and May, and grows to a height of 10-30cm (4-12in).

Below: Yellow bird's nest (*Monotropa hypopitys*) is a saprophytic species, living on the decaying vegetable matter of woodland floors. It flowers in the summer and can be 30cm (1ft) tall.

green plants can survive.

The bird's nest orchid is a difficult plant to spot because its erect brownish stems blend in well with the background so that, at first glance, it looks like the withering remains of a once-green plant. Its name describes the tangled mass of roots at its base, thought to resemble a bird's nest. Yellow bird's nest looks similar but has yellowish stems, which nod when in flower and have an unmistakable waxy appearance.

Although yellow bird's nest and bird's nest orchid are generally known as saprophytes, they are unable to utilise nutrients directly from the decaying plant material. This is because they lack the necessary chemicals to break down the organic matter into simple substances that can be absorbed easily. Instead, the decaying material is broken down by a saprophytic fungus living on the plant's roots, an example of a mycorrhizal relationship. It is thought that the fungus also helps the roots of the plant to absorb water.

Partial parasites Totally parasitic plants are uncommon in Britain but there are many that are partially parasitic. They are green (more often, a distinctive yellowish-green) and therefore capable of manufacturing some of their own food, but they also obtain additional water and nutrients from a host plant.

The most familiar partial parasite is mistletoe but there are many others, for example, the yellow rattles, the cow-wheats and the eyebrights, which are all members of the figwort family, Scrophulariaceae, and are partially parasitic on grass roots. They attach themselves to the host, and draw nourishment from it by means of small suckers called haustoria. Partial parasites are not as damaging to their hosts as complete ones.

UNDERWATER FORESTS

Britain's sunken kelp forests, some exposed only at low tide and others not at all, are a living testament to the variety and complexity of our marine life.

A large part of our countryside was once covered by dense forest – an impressive habitat now modified and restricted by man's activities. However, a truly wild and natural forest still exists for us to explore: the kelp forest of the sea.

Kelp is a general term used to describe an order (Laminariales) of large brown seaweeds, most of which reach several metres in length and have such descriptive names as oar weed, tangle, cuvie, sugar kelp, sea belt and poor man's weather glass. The most familiar species are the sugar kelp (*Laminaria saccharina*) and the tangle (*Laminaria digitata*), whose wavy fronds and droopy heads can be seen on rocky shores at very low spring tides. However, Britain's main kelp forest is formed by a similar species, *Laminaria hyperborea*, which occurs only below the low-water mark. Kelp forest is the natural vegetation in the shallow waters around Great Britain, except on the coasts of East Anglia and south-east England, which lack a suitable rocky substrate.

The complex structure and beauty of a kelp forest rivals the more familiar oak and beech woodlands. One of the earliest naturalists to explore this unknown forest was J A Kitching who, in the 1930s, walked down into a forest with a bucket on his head, a breathing hose and a pair of garden shears! Today, modern SCUBA techniques have made exploration of this habitat much easier.

Below: Kelp can develop into marine forest only where there are large rocks to which the plants attach themselves. Here, tangle retains its grip with large holdfasts that anchor the plant and ensure it is not swept away.

Holdfasts True kelp forest develops only on solid stable rock to which the plants can attach themselves by means of large holdfasts. The holdfast of a seaweed acts as an anchor to prevent the plant from being swept away by waves and current. Areas of mobile boulders and pebbles may be dominated by other kelps such as the sugar kelp, which can tolerate a mobile substratum, and by opportunistic species capable of rapid growth following winter storms.

Kelp depends on sunlight for photosynthesis, as do most plants. The amount of light available in the sea decreases rapidly with depth, especially in turbid and polluted waters. In the Menai Straits, where the water is often murky, the kelp forest stops at the depth of only 2-3m (6-10ft) below extreme low water, whereas in the clear waters of south-west Britain and the west coast of Scotland it may extend to 30m (100ft) or more.

Structure of the forest The density and size of individual kelp plants in the forest depend on environmental conditions, particularly on

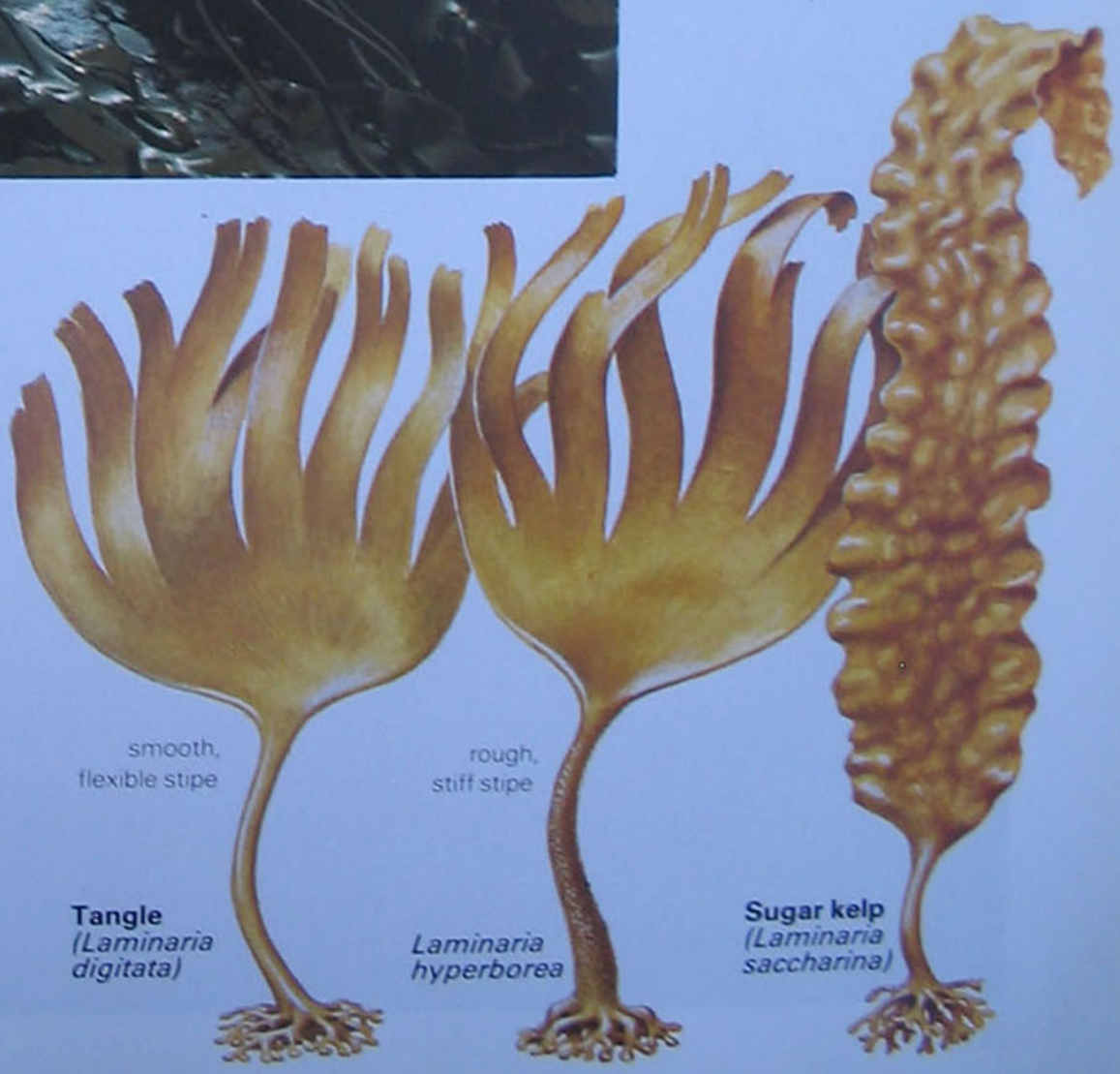
Left: As the tide comes in, it gradually washes over the exposed kelp so that the matted growths are once again hidden by the sea.

Three types of kelp

Most of Britain's kelp forest consists of tangle (also known as oarweed), sugar kelp or *Laminaria hyperborea*, which has no common name. Tangle is exposed during the very low spring tides, when its wavy fronds and droopy heads can be seen, but *L. hyperborea*, Britain's main species of kelp forest, grows only below the low-water mark. Sugar kelp is one of the few that can survive on loose boulders and pebbles; most kelp species require a solid stable substrate such as rock on which to live. These large brown seaweeds may grow to lengths of several metres around the coast of Great Britain in the shallow waters where there is sufficient light for their survival.

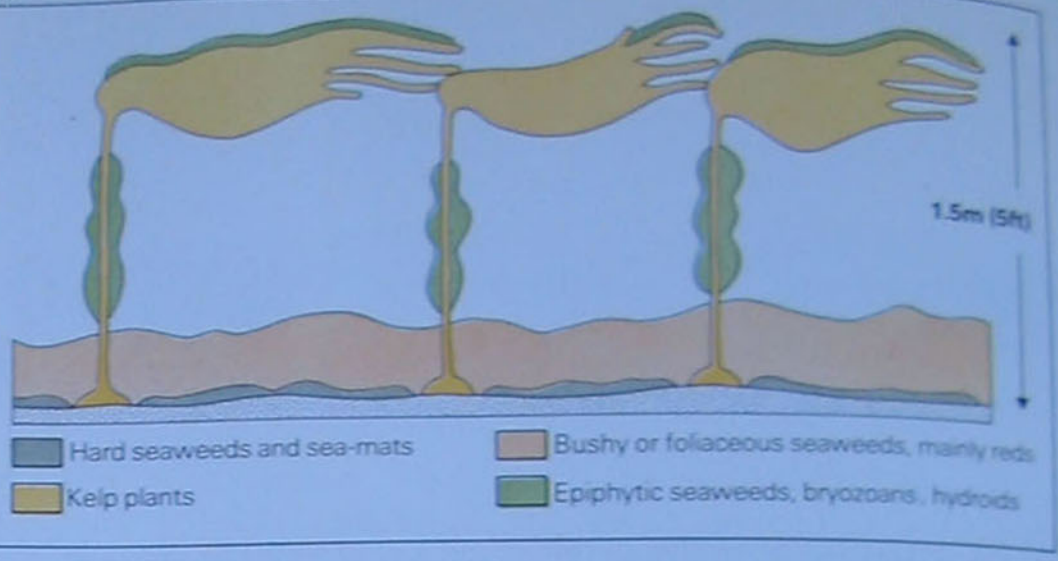
the strength of wave action and tidal streams. The thickest forests are found in areas of moderate wave action where conditions are most stable. The plants in such a forest grow so close together that it is difficult for a diver to swim between them. In shallow water exposed to considerable wave action older plants are continually pulled off the rocks, and so most of the plants are young and small. The forest also thins out with increasing depth and forms a kelp 'park' where individuals are widely spaced, just as are the trees in a city park.

The kelp forest has a vertical structure with several layers comparable to those of a typical woodland. The rock itself often appears pink, brown or even orange due to a crust of hard seaweeds such as *Lithothamnion* and to encrusting sea mats (Bryozoa). This ground layer is formed by lichens and mosses in a woodland. Next comes a layer of bushy or foliaceous seaweeds, mainly reds, whose density and variety depend on the available light and on grazing pressure. Among the seaweeds there will also be animal growths–



Layers of a kelp forest

A woodland can be divided into a variety of different layers, each layer higher than the last, and so too can a kelp forest. The lowest layer comprises the encrusting seaweeds and sea-mats that cover the rocky substrate. Above that comes a layer of bushy seaweeds, among which can be found a variety of marine animals, notably sea-anemones, bryozoans and hydroids. Then comes the layer of kelp itself, providing the forest with its canopy. Most kelp forests also have a fourth layer, consisting of epiphtyic seaweeds and animals such as limpets and sea-urchins, that live on the canopy.



hydroids, bryozoans and sea-anemones, in every way as colourful as the bluebells, ferns and grasses making up the herb layer in the woodland. Finally, there are the trees of the forest: the kelp plants themselves.

The forest may have a fourth layer comprising the epiphytic seaweeds and the animals that survive on the kelp.

The richness of the forest undergrowth is also affected by the grazing activities of animals such as sea-urchins and limpets. In Scottish waters, where the sea urchin *Echinus esculentus* is common, the rock surface may be bare of all except the hard-encrusting seaweeds and a few tube worms and barnacles. In contrast, kelp forests that occur in areas of high water currents – narrows, rapids or surge gullies – may have a very rich undergrowth of animals, such as sponges and sea-squirts, which depend on a current to bring them food. No such static animal life is found in a woodland.

The forest habitat The kelp forest provides a place to live and a source of food for a wide variety of species. More than 300 species of animals have been found hidden among the tangled rootlets, including worms, crustaceans, molluscs, brittlestars and sea-anemones. The older and larger the holdfast, the greater the number of species. Some remain permanently in this refuge, whereas for others it is a temporary home while young and

Below: As underwater kelp forests form only below the low-water mark they remain hidden to the land-based observer. Only divers can explore this strange habitat, and they are invariably astonished by the beauty and variety of their first kelp forest, the clustered holdfasts of which may harbour as many as 300 different species of sea-anemones, molluscs, worms and crustaceans.

vulnerable.

The stipe and frond provide attachment for a wide variety of epiphytic species. The bryozoan *Membranipora membranacea* spreads its beautiful white lacework over the surface of the frond; and the delicate hydroid *Obelia dichtoma* forms its own miniature forest of tiny threads. Life on the kelp frond exposes these animals to the water current with its food supply and keeps them out of the silt. Life on the stipe provides the seaweeds with increased illumination and, although most epiphytic species grow just as well on rock, some prefer the stipe as a habitat and even particular parts of it. Dulse (*Palmaria palmata*), a common red seaweed, is generally found at the top of the stipe on plants in shallower water where the light is greatest.

Feeding on kelp Some animals graze the kelp. The most beautiful, but also the most damaging, is the blue-rayed limpet which chews its way into the plant until it is almost buried. The sea-urchin *E. esculentus* is often found climbing up the stipe and grazing both the kelp itself and the epiphytes on it. *E. esculentus* can also prevent recolonization by grazing the young kelp sporelings, just as deer and rabbits do to young trees.

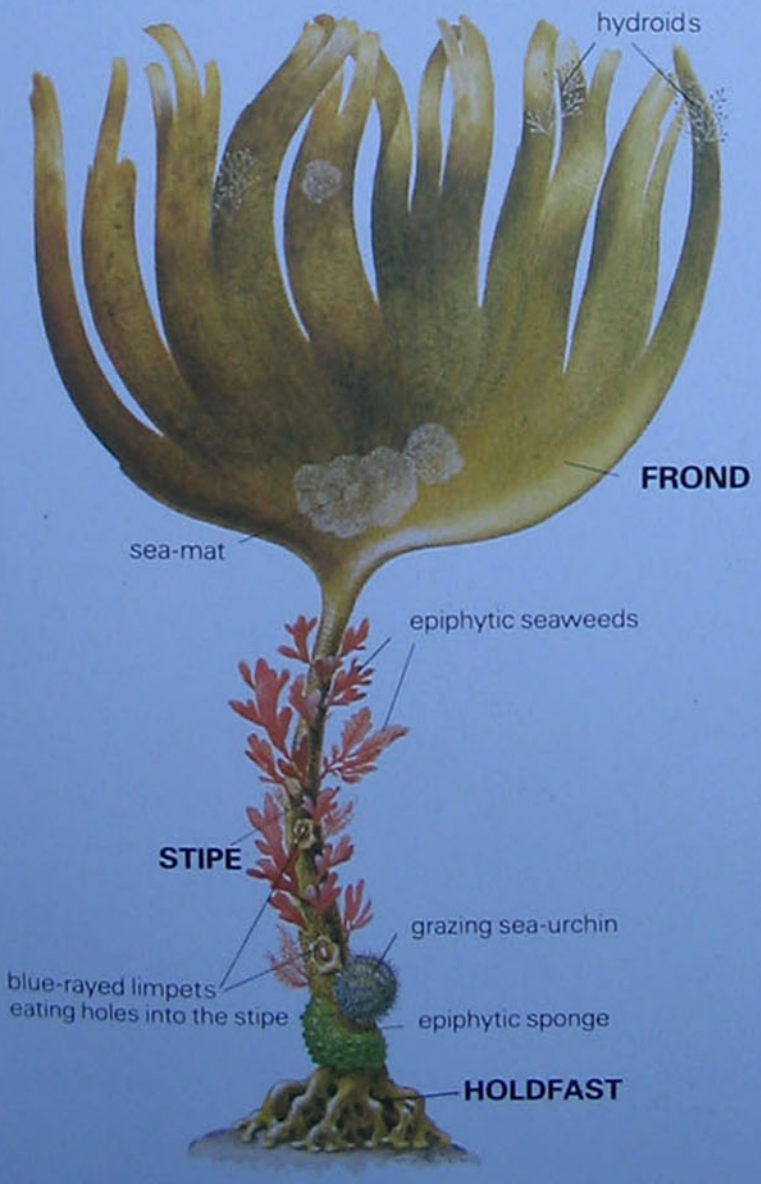
Many other animals do not rely directly on the kelp for food or support, but instead use the forest as a hunting ground. Fishes, crabs, lobsters and other mobile animals explore the forest for food. Shoals of pollack and saithe, two members of the cod family, are a common sight just above the canopy, and wrasse swim busily between the stipes. Slow-moving predators, such as starfishes and colourful sea slugs, move around on the bottom and over the kelp plants searching for food. In contrast to the colourful sea slugs are the camouflage experts: small species of spider crabs such as *Inachus* and *Macropodia* decorate themselves with pieces of sponge and seaweed and sit quietly disguised on the kelp.

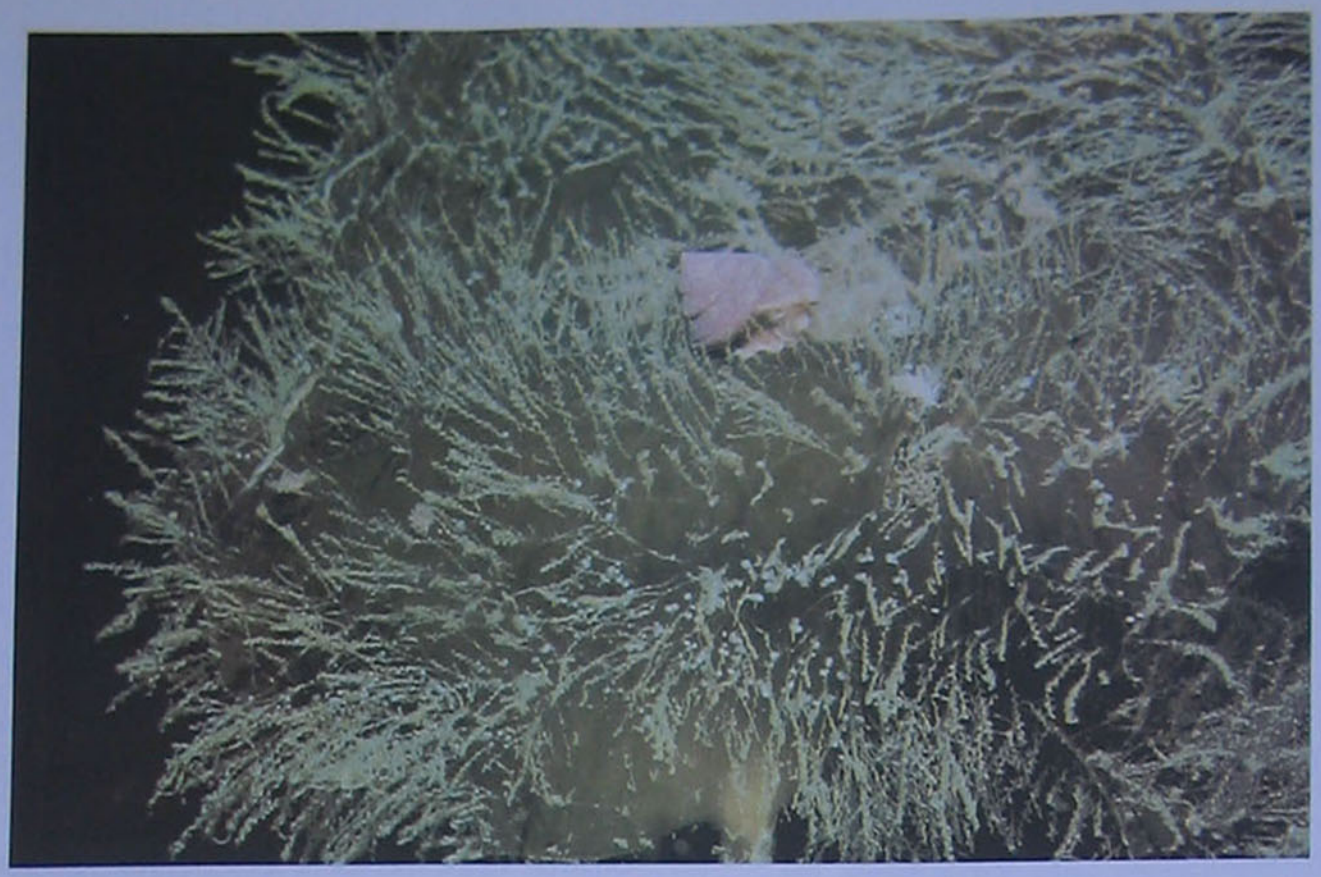
The changing forest The kelp forest changes with the changing season. Each year the kelp frond is shed, just like the leaves of a tree, although at different times and for a different reason. A new frond starts to grow below the

Above: In areas where the water is clear and can let through enough light to support plant-life, kelp forests can be found growing as deep as 30m (15 fathoms). In murkier waters, however, such as in the Menai Straits, the forest may penetrate only as deep as 2-3m (about a fathom).

Below right: Full diving apparatus is necessary to explore the spectacular scenery of a kelp forest.

The life that dwells on kelp





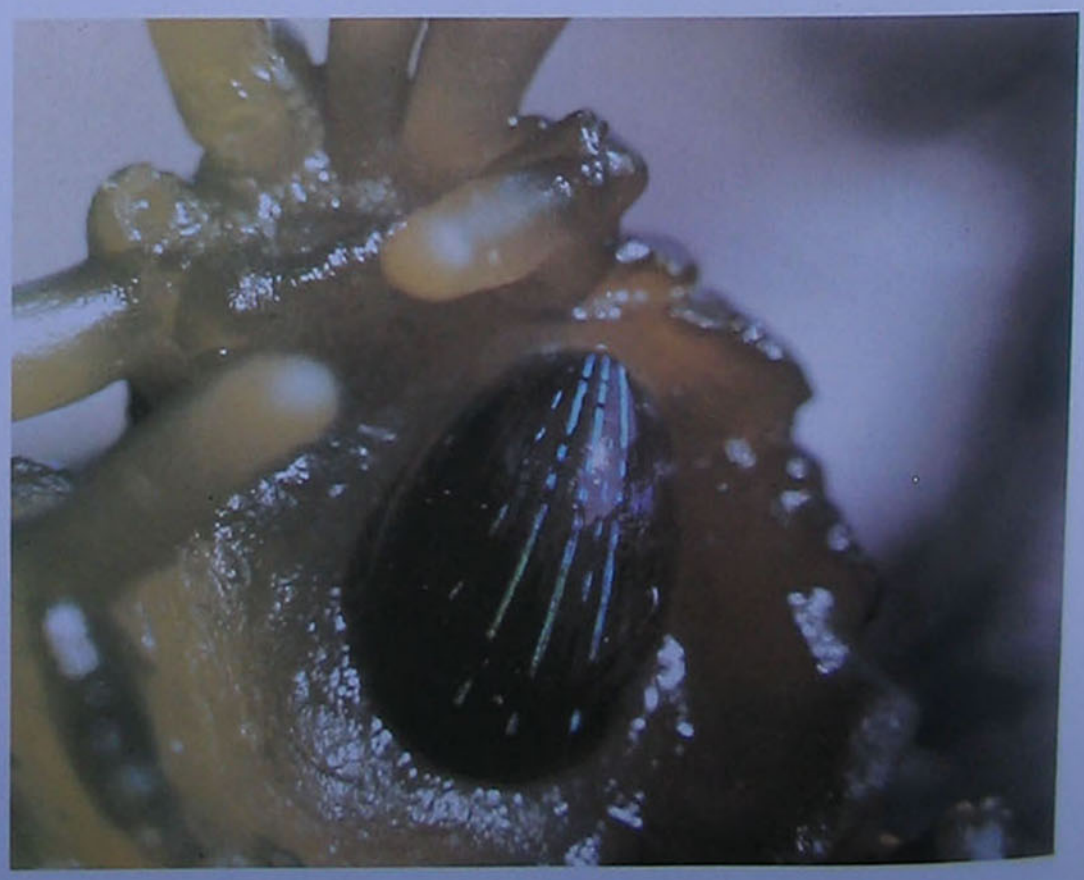
Left: The delicate fronds of the hydroid *Obelia geniculata* have formed a dense miniature forest among the holdfasts on the floor of the kelp forest. The older, larger holdfasts make especially good homes for such species, which derive not only shelter, but a constant food supply as well, as a result of the current, which in turn prevents them becoming clogged in silt. In this photograph a top shell, *Calliostoma zizyphinum*, has come to rest among the swirling fronds.

old one in November and reaches full size in about April. The old frond eventually breaks off from the new during March, April or May and enormous masses of kelp fronds are cast up on to the beaches. By the end of the season, most kelp fronds have a heavy load of epiphytes and these too are lost with the old frond. The forest in spring then looks 'clean' until the epiphytes catch up again.

Under the right conditions a single kelp plant can live for more than 10 years. Age can be estimated from annual growth rings just as in trees, although it is not as accurate. The kelp plant grows from the transitional zone between the stipe and the frond, and the stipe increases in length each year. In old plants it may reach 3m (10ft). These older plants are susceptible to storm damage, however, and in winter many are torn from the rocks and die. The holes made in the holdfasts and stipes by the blue-rayed limpet hasten the process by weakening the plant in a variety of different places.

Inside the kelp forest the undergrowth changes with the season. Many red seaweeds are annuals and die with the onset of winter. Bryozoans and hydroids may also die back or are grazed until they become inconspicuous. In spring, gaps left by storm damage may be quickly colonized by opportunistic species which are later overgrown by larger slow-growing species.

Below: The form and size of a kelp forest is constantly subject to change, partly as a result of the action of the sea and partly because some animals graze upon the kelp and ultimately damage it. The blue-rayed limpet is one of the chief menaces, for it attaches itself to the kelp, chewing its way into the plant until it is practically buried. The holes that the blue-rayed limpets make in the kelp's holdfasts eventually weaken the plant until, combined with the action of rough seas, the kelp weakens and dies.

Uses of kelp

Man makes a limited use of the enormous quantity of plant material available in a kelp forest. In the past ash from burned kelp was used as a source of soda for the glass industry and for producing iodine. However, there are now alternative sources for these products and the main use nowadays for kelp is in the manufacture of chemicals called alginates, which are used in the pharmaceutical and food industries and in printing processes. Most alginates are manufactured in Britain and Norway. In Britain, they are made from kelp gathered from material cast up on the shore, only the stipes being dried and used for the alginate industry. In Norway some of the kelp is harvested by special dredges which cut the plants off the rock just above the holdfast; in this case both the frond and the stipe are utilised.
Small amounts of kelp are also made into animal feeds and liquid fertilisers, though knotted wrack, another brown seaweed, is more commonly used for this.